PART II

TECHNICAL APPROACHES AND POLICY OPTIONS FOR REDUCING GREENHOUSE GAS EMISSIONS

The following two chapters provide an overview of specific steps states might take to reduce greenhouse gas emissions.

- Chapter 5, *Technical Approaches and Source-Specific Policy Options*, is broken into twelve sections, each corresponding to a single emissions source. It provides background technical information and offers policy options for addressing each source.

- Chapter 6, *Cross-Cutting Themes and Program Development*, discusses policy options and issues that are relevant to more than one emissions source and indicates areas with the greatest potential for comprehensive emission reduction measures.

These chapters are designed to be used as reference materials, providing self-contained information on each emissions source. Each section provides references to other sections where appropriate. These chapters are not necessarily intended to be read through in a comprehensive way.

These chapters present policy suggestions that generally follow the structure described in Chapter 2 for addressing specific barriers to greenhouse gas emission reductions. In this context, the policy options here fit generally into four categories: education and information provision, restructuring of institutional and legal barriers, development of financial incentives, and direct regulation.

Greenhouse Gas Sources Not Elaborated in this Document

This document does not elaborate on several sources of greenhouse gases, such as methane emissions from wastewater treatment and wetland drainage and carbon loss from soils. These sources are difficult to address for various reasons. In some cases, the current scientific understanding of the emission source is insufficient to warrant thorough discussion. Similarly, the scientific uncertainties surrounding the emission reduction options for these sources are often too great to consider such measures as viable alternatives. For other emission sources, there are no viable technical approaches to reduce emissions effectively.

Rather than to address these tangential sources, this document emphasizes areas where states can focus their efforts and resources to mitigate significantly the threat of future climate change. States should, however, still include these sources as part of a complete greenhouse gas emissions inventory since they are a part of a state's overall contribution to global warming. The most significant sources not elaborated in detail in Chapters 5 and 6 are summarized below.

- *Wetlands Drainage*: This document does not contain emission reduction measures for wetland drainage because of the potentially offsetting effects of this activity on climate change. That is, wetland drainage may decrease emissions of one greenhouse gas, methane, while increasing emissions of another, carbon dioxide. Wetlands drainage results in a reduction of methane uptake and an increase in carbon dioxide emissions as the soils change from an anaerobic to an aerobic state. However, depending on the fate of the drained wetlands, these soils may also become a net sink of methane. It is difficult, therefore, to quantify the net effect of any reduction measures. Furthermore, while net emissions of nitrous oxide and carbon monoxide may be affected by this activity, the direction and the magnitude of the effects on these gases are highly uncertain. It may be more useful for states to implement policy measures that have a clearer mitigative impact.

- *Conversion of Grasslands to Cultivated Lands*: This document does not address conversion of natural grasslands to managed grasslands and to cultivated lands because of the scientific uncertainties associated with this emissions source. Conversion of natural grasslands to managed grasslands and to cultivated lands may affect net carbon dioxide, methane, nitrous oxide, and carbon monoxide emissions. Conversion of natural grasslands to cultivated lands may result in carbon dioxide emissions due to a reduction in both biomass carbon and soil carbon. Such a land use change has been found (at least in the semi-arid temperate zone) to also decrease carbon dioxide uptake by the soils. The effects on nitrous oxide and carbon monoxide fluxes are highly uncertain.

- *Greenhouse Gases from Production Processes*: Direct greenhouse gas emissions from the industrial sector result from a variety of chemical, thermal, and mechanical processes that are employed to extract, refine, and process raw materials and produce a variety of end-products. For example, aside from the emissions resulting from on site power generation and heating, a significant amount of carbon dioxide is released during cement production. Similarly, nylon production results in the release of nitrous oxide. Section D in the Phase I document contains a list of additional industrial processes that produce greenhouse gas emissions. Because there are few additional reduction measures currently available, this document does not address other greenhouse gas emissions reductions from this source category. The most effective emissions reduction method for the industrial sector usually is to improve energy efficiency, which is discussed in Section 5.1.5.

- *Methane from Wastewater Treatment Facilities*: Anaerobic treatment of wastes produces methane. This is generally considered to be a bigger problem in many developing countries than in the United States, since most U.S. facilities treat waste aerobically. In addition, many municipal waste water treatment facilities in the U.S. already capture the methane they do produce and use it during on-site energy production. While not addressed further in this chapter or the Phase I *States Workbook*, policy-makers should consider this issue as it applies to their local circumstances.

- *Emissions of Ozone-Depleting Substances*: This document does not address emissions of CFCs and other Ozone-Depleting Substances (ODSs) that, in addition to depleting stratospheric ozone, also function as greenhouse gases. This document also does not address the greenhouse effect of many of non-ozone depleting chemical replacements for the ODSs, such as hydrofluorocarbons (HFCs). ODSs and HFCs are emitted as a result of a variety of processes, including refrigeration, air conditioning, solvent cleaning, foam production, and aluminum production. Emissions of ODSs, except for those stemming from aluminum production, are already rapidly declining. They are being phased out under the *Clean Air Act Amendments of 1990* in coordination with U.S. obligations as a signatory to the *Montreal Protocol on Substances that Deplete the Ozone Layer*. CFC replacements such as HFCs, on the other hand, are controlled under EPA's Safe New Alternatives Program (SNAP) and are targeted for certain actions under the *Climate Change Action Plan*.

Additional Information on Policies and Actions to Reduce Greenhouse Gas Emissions

The CCAP presents a variety of programs and actions the federal government will be undertaking to reduce greenhouse gas emissions. Exhibit II-1 lists the specific actions highlighted in the CCAP. Many of these may supplement the policy ideas elaborated in Chapters 5 and 6. A copy of the CCAP can be obtained from EPA.

Exhibit II-1: Actions Specified in the U.S. Climate Change Action Plan

Foundation Actions
- Launch the Climate Challenge to encourage electric utilities and other eligible firms to submit voluntary greenhouse gas reduction portfolios
- Launch Climate-Wise Companies to encourage U.S. industry to take advantage of the environmental and economic benefits associated with enrrgy efficiency improvements and greenhouse gas emission reductions

Commercial Energy Efficiency Actions
- Coordinate *DOE Rebuild America and EPA Energy Star Buildings*
- Expand EPA's *Green Lights* Program
- Establish State Revolving Fund for Public Buildings
- Expand Cost-Shared Demonstrations of Emerging Technologies
- Establish Energy Efficiency and Renewable Energy Information and Training Programs

Residential Energy Efficiency Actions
- Form *Golden Carrot* Market-Pull Partnerships
- Enhance Residential Appliance Standards
- Promote Home Energy Rating Systems and Energy-Efficient Mortgages
- Expand *Cool Communities* Program in Cities and Federal Facilities
- Upgrade Residential Building Standards
- Create Residential Energy Efficiency Programs and Housing Technology Centers

Industrial Energy Efficiency Actions
- Create a Motor Challenge Program
- Establish Golden Carrot Programs for Industrial Air Compressors, Pumps, Fans and Drives
- Accelerate the Adoption of Energy-Efficient Process Technologies Including the Creation of One-Stop-Shops
- Expand and Enhance Energy and Diagnostic Centers
- Accelerate Source Reduction, Pollution Prevention, and Recycling
- Improve Efficiency of Fertilizer Nitrogen Use
- Reduce Pesticide Use

Transportation Actions
- Reform the Federal Tax Subsidy for Employer-Provided Parking
- Adopt a Transportation System Efficiency Strategy
- Promote Greater Use of Telecommuting
- Develop Fuel Economy Labels for Tires

Energy Supply Actions
- Increase Natural Gas Share of Energy Use Through Federal Regulatory Reform
- Promote Seasonal Gas Use for Control of Nitrogen Oxides (No_x)
- Commercialize High Efficiency Gas Technologies
- Form Renewable Energy Market Mobilization Collaborative and Technology Demonstrations
- Promote Integrated Resource Planning
- Retain and Improve Hydroelectric Generation at Existing Dams
- Accelerate the Development of Efficiency Standards for Electric Transformers
- Launch EPA *Energy Star Transformers*
- Reduce Electric Generation Losses Through Transmission Pricing Reform

Methane Reduction and Recovery Actions
- Expand *Natural Gas Star*
- Increase Stringency of Landfill Rules
- Expand Landfill Outreach Program
- Launch Coalbed Methane Outreach Program
- Expand RD&D for Methane Recovery from Coal Mining
- Expand RD&D for Methane Recovery from Landfills
- Expand *AgStar* Partnership Program with Livestock Producers
- Improve Ruminant Productivity and Product Marketing

HFC, PFC and Nitrous Oxide Reduction Actions
- Narrow Use of High GWP Chemicals Using the Clean Air Act and Product Stewardship to Reduce Emissions
- Create Partnerships with Manufacturers of HCFC-22 to Eliminate HFC-23 Emissions
- Launch Partnership with Aluminum Producers to Reduce Emissions From Manufacturing Processes
- Improve Efficiency of Fertilizer Nitrogen Use

Forestry Actions
- Reduce The Depletion of Nonindustrial Private Forests
- Accelerate Tree Planting in Nonindustrial Private Forests
- Accelerate Source Reduction, Pollution Prevention and Recycling
- Expand *Cool Communities* Program in Cities and Federal Facilities

CHAPTER 5
TECHNICAL APPROACHES AND SOURCE-SPECIFIC POLICY OPTIONS

This chapter describes opportunities for state policy-makers to control greenhouse gas emissions from specific sources. To facilitate presentation, these opportunities have been divided into technical approaches and policy options. "Technical approaches" refer to technical or engineering methods which, when implemented, will reduce emissions from the source category. "Policy options" are instruments through which one or more technical approaches are promoted. Exhibit 5-1 illustrates how these terms are used in this chapter.

Exhibit 5-1
Examples of Terminology Used in Chapter 5

Source Category	**Technical Approach**	**Policy Option**
Greenhouse Gases from the Transportation Sector	Reduce Vehicle Miles Traveled	• Improve Mass Transit Systems • Provide Incentives to Employees to Establish Van Pools • Develop Tele-Commuting Programs
Methane from Landfills	Recover and Use Methane Gas	• Sponsor Technology Demonstration Projects • Develop Tax Credits for Methane Recovery Projects • Initiate Regulatory Requirements to Capture Gas

Information regarding emissions, and approaches to reducing emissions, are not always easily categorized for policy analysis. The emissions sources or grouping of gases to prepare emissions inventories are often scientifically based and do not necessarily support effective policy analysis and development. This part of the document is generally organized around the emissions source categories from the *States Workbook*, but adjusts those categories where appropriate to facilitate policy development. Exhibit 5-2 shows the relationship between the emissions sources defined in the *States Workbook* and categories used to organize this chapter.

Within each source category information is presented in the following format:

- An *introduction* to the source category summarizes how specific greenhouse gases are generated and emitted by the source and discusses federal, state, and local policy objectives that may be relevant to emission reductions.

Exhibit 5-2

Emissions Source Category As Defined in Phase I Workbook		Source Categories Described in Chapter 5 of This Document
Greenhouse Gases from the Residential Sector	➤	Greenhouse Gases from Energy Consumption: Demand-side Measures
Greenhouse Gases from the Commercial Sector	➤	
Greenhouse Gases from the Industrial Sector	➤	
Greenhouse Gases from the Electric Utility Sector	➤	Greenhouse Gases from Electricity Generation: Supply Side Measures
Greenhouse Gases from the Transportation Sector	➤	Greenhouse Gases from the Transportation Sector
Greenhouse Gases from Production Processes	➤	Not addressed in Chapter 5
Methane from Oil & Natural Gas Systems	➤	Methane from Oil & Natural Gas Systems
Methane from Coal Mining	➤	Methane from Coal Mining
Methane from Landfills	➤	Methane from Landfills
Methane from Domesticated Animals	➤	Methane from Domesticated Animals
Methane from Manure Management	➤	Methane from Animal Manure
Methane from Flooded Rice Fields	➤	Methane from Flooded Rice Fields
Nitrous Oxide from Fertilizer Use	➤	Nitrous Oxide from Fertilizer Use
Greenhouse Gases Due to Changes in Forests and Woody Biomass Stocks	➤	Emissions Associated with Forested Lands
Greenhouse Gas Reductions/Sequestration from Forestry Projects	➤	
Greenhouse Gases Due to Conversion of Grasslands to Cultivated Lands	➤	Not addressed in Chapter 5
Greenhouse Gas Emissions from the Abandonment of Managed Lands	➤	Not addressed in Chapter 5
Methane Emissions from Wastewater Treatment	➤	Not addressed in Chapter 5
Greenhouse Gases from Burning of Agricultural Wastes	➤	Greenhouse Gases from Burning of Agricultural Wastes

- Each *technical approach* to emissions reduction is presented, including a general description of the approach along with associated administrative and implementation considerations, such as emission reductions, cost, time frame, key drawbacks or limitations, possible ancillary effects, and related examples.

- *Policy options* for each technical approach suggest ways state governments might be able to promote and implement that approach, drawing from a wide variety of perspectives and examples.

As the introduction to Part II of this document explains, "cross-cutting" issues or policy options that potentially affect more than one source category in this chapter are elaborated in Chapter 6. One important cross-cutting issue of which policy-makers should be aware, and that affects or is affected by all source categories, is that greenhouse gases are linked to energy consumption in all sectors. While Section 5.1 examines this issue, it is important to note that energy consumption in all sectors of society result in greenhouse gas production. This encompasses, for example, agricultural, forestry, industrial, and residential concerns. This issue is too broad to examine exclusively and concisely without considering its relevance in the context of all other emission sources. Accordingly, the rest of this document makes specific reference to energy consumption issues where appropriate.

The information summarized in this chapter is designed to be used selectively, allowing policy-makers to focus on the specific sources in which they are most interested. This document does not advocate particular approaches or options.

5.1 GREENHOUSE GASES FROM ENERGY CONSUMPTION: DEMAND-SIDE MEASURES

Carbon dioxide is emitted through combustion of fossil- and biomass-based fuels to produce direct heat and steam, and to generate electricity, either at utility plants or directly on-site where the energy will be consumed. The amount of carbon dioxide released to the atmosphere is directly proportional to the carbon content of the fuel used. Coal is the most widely used of all fossil fuels for electricity generation and has the highest carbon content, natural gas is second in electricity generation use while third in carbon content, and oil is third for electricity generation but second in carbon content.[1] In the U.S., electricity use by the residential, commercial, and industrial sectors each accounts for about one-third of total carbon dioxide emissions.

Several perspectives may help policy-makers identify measures to decrease energy sector carbon dioxide emissions:

- First, emissions reductions can be achieved through actions taken either to reduce energy consumption or to alter energy supply.

- Second, these actions can reduce emissions either by reducing energy consumption or by improving the efficiency with which energy is used. Decreasing the number of processes used, commonly called energy conservation, requires a reorientation of business practices and lifestyles, such as utilizing different transportation networks or following non-typical work schedules. Energy-efficiency options, on the other hand, achieve the same level of output or activity while using less energy, often through improved technology. A more efficient furnace, for example, may allow a household to maintain the same or even higher indoor temperature while using less fuel.

  Third, either energy conservation or energy-efficiency options on the consumption- or supply-side can be exercised using a variety of policy levers. At the state level this usually means either undertaking direct energy planning and programmatic initiatives through state energy, natural resources, and economic development offices (as many states have since the mid-to-late-1970s), or using utility regulatory authority to encourage or mandate utility involvement in energy

[1] The burning of biomass-based fuels (wood, agricultural refuse, etc.) also releases carbon dioxide. However, biomass burning releases carbon that was sequestered from the atmosphere to begin with, rather than releasing carbon that was previously stored deep in the earth as is the case with fossil fuels. In this context, combustion of biomass fuels that are sustainably grown (meaning each time biomass crops are harvested they are replaced with new plants and trees) does not significantly affect the atmospheric carbon balance while burning fossil fuels does.

conservation, energy efficiency, and load management programs (as has been done increasingly since the 1980s).

The remainder of Section 5.1 addresses energy consumption. It identifies technical approaches for improving energy efficiency and briefly outlines both direct state actions and regulatory agency-driven utility actions to implement those approaches. Section 5.2 presents energy production issues. Chapter 6 discusses specific policy options for reducing energy demand and increasing supply of low-carbon or no-carbon energy.

While separated here for descriptive clarity, these three sections are linked and should be considered together during policy analysis and development. Each section, for example, highlights how both the consumers and the producers of electricity can take actions to affect energy demand and supply, and each section also points out how, in many circumstances, certain facilities can simultaneously act as energy consumers and producers. Because of wide variations among the states, the information provided here should be considered as background to be investigated and clarified further as it applies to distinct state circumstances.

Introduction To Consumption-Side Issues and Demand-Side Management

Between 1973 and 1986, conservation and efficiency measures, combined with strategic energy planning and increased use of renewable energy sources, helped keep U.S. energy consumption at nearly constant levels while the country's gross national product grew by thirty-five percent. This demonstrates the significant potential for reducing the economy's energy intensity. Enormous opportunities for further demand reduction are still available using existing and newly developed conservation and efficiency measures.

Demand-side management (DSM) is the term for programs that focus on getting end-users to consume less energy. These programs are administered by a wide range of entities, ranging from utilities to state agencies, local governments, community action agencies, and not-for-profit organizations. Basic types of demand-side management programs include:

- Building or business audits to identify potential energy savings;
- Performance based rebates paid on a per-kilowatt or per-kilowatt conserved basis;
- Technology based rebates for specific energy-efficiency measures such as compact fluorescent lights and occupant sensing light switches;
- Reduced interest financing for energy-efficiency investments;
- Direct installation of energy-efficient equipment;
- Energy load management programs designed to shift consumption of energy to different times of the day, including time-of-day pricing and peak-load pricing, imposition of demand charges, and voluntary load shifting agreements with particular commercial and industrial customers;

- Educational and advertising campaigns targeted either at the general public or at specific commercial or industrial sectors; and

- End-use fuel substitution.

A large array of federal, state, and local policies affect the energy sector and influence demand-side issues. The Federal Energy Regulatory Commission (FERC), for example, has jurisdiction over wholesale (inter-utility) power transactions and natural gas transportation, while states have traditionally regulated utilities through public utility commissions (PUCs), which oversee rate setting and approve energy supply expansion and power plant construction. Additionally, pollutant discharges from utilities are regulated by an intertwined network of federal, state, and local environmental statutes. Federal laws that directly affect energy-related emissions and the operation of utility companies include the Clean Air Act (CAA), the Public Utilities Holding Company Act (PUHCA), the Public Utilities Regulatory Policies Act (PURPA), the Federal Power Act, the Natural Gas Policy Act, and the Energy Policy Act of 1992 (EPAct). Additionally, the federal government administers several programs to encourage energy efficiency and demand-side management. These include, for example, EPA's "Green Lights" program, which provides information, education, and technical assistance to businesses and state and local governments to encourage use of energy-efficient lighting. EPA has expanded this voluntary program to include other energy uses such as heating and cooling, industrial motors, and computer equipment in its Energy Star program. In addition, the Department of Energy (DOE) sets minimum energy-efficiency standards, under the National Appliance Energy Conservation Act (NAECA), for certain appliances. DOE also administers many programs to research and promote energy efficiency, including public information initiatives requiring disclosure of efficiency ratings for competing appliances and programs that target research on energy use in buildings.

Exhibit 5-3: EPA's Energy Star Buildings and Green Lights Program

EPA's Energy Star Buildings and Green Lights Program is designed to reduce pollution, promote public-private partnerships, use market forces, and recognize environmental leadership. Participants in the Program sign a Memorandum of Understanding committing them to perform upgrades where profitable — Green Lights participants upgrade lighting within 5 years, and Energy Star Buildings participants fulfill Green Lights commitments and perform whole-building upgrades within 7 years. In return, EPA provides technical support targeted to overcome barriers, such as state-of-the-art software to support decision-making, technical information on building systems, reports on lighting products, and networking with equipment manufacturers. EPA also provides opportunities for public recognition.

As of August 31, 1997, there were 2,487 participants, whose combined commitment to perform lighting upgrades exceeded 5.5 billion square feet. The annual emissions avoided by the program is estimated at over 3 million tons of CO_2, 25,000 tons of SO_2, and 11,000 tons of NO_x. In terms of energy, over 4.5 billion kWh, or $335 million, has been saved. For more information, contact the Energy Star & Green Lights Hotline at 888/STAR-YES.

State and local governments have enormous opportunity to supplement federal actions because they retain jurisdiction in policy areas, including utility rate reform, city and regional planning, and establishing building codes (see Chapter 6). In addition, proximity to local energy use allows states to promote policies that considers their unique opportunities and constraints.

Through greenhouse-gas reducing actions in the energy sector, state and local governments also support other policy objectives. Foremost, policies that affect energy consumption and production can reduce emission of air and water pollutants and support local economic development. For example, some states are promoting and supporting energy efficiency as a way of lowering industry costs in order to attract investments and increase their state's economic productivity and competitiveness.

However, demand-side management programs around the country have often been slow to take hold as an effective mechanism for helping regions meet their energy needs. While the technologies to support large-scale energy efficiency have existed for several years, those technologies in most cases have not substantially penetrated the residential, commercial, or industrial sectors. This problem is rooted in a set of common institutional and political barriers, summarized below, that either prevent development of more energy-efficient practices or actually promote wasteful actions:

- *Perceived High Initial Cost and Delayed Return on Investment in Energy Efficient Technology*. Many energy efficient technologies have higher up-front costs than the standard technologies they could replace. Compact fluorescent light bulbs, for example, can cost up to fifteen times as much as standard incandescent bulbs; the value of the electricity savings, however, significantly outweighs these costs but may not be realized for some period of time. Consumers and firms may accordingly choose not to make the investment. Additionally, new technologies can require extra time and effort to install and potential consumers often view installation as contributing to initial costs.[2]

- *Lack of Information*. Consumers and firms are often uninformed about the cost, performance, and reliability of efficient technologies. Furthermore, preconceptions of problematic early energy-efficiency technologies persist, and may dissuade consumers from choosing energy efficient products and processes. In general, people are also unaware of the connection between energy usage and environmental degradation.

- *Low Priority Given to Energy Consumption.* Energy costs typically represent a small fraction of a firm's overall budget; businesses focused on producing quality products for customers often overlook opportunities for savings through energy efficiency.

- *Low Energy Costs*. Low energy costs have the dual effect of reducing the need for energy efficiency in consumers' minds and reducing the return of investments in energy-efficient technology.

- *Limited Availability*. Energy-efficiency technologies in the residential, commercial, and industrial sectors are generally available only in selected geographic areas, often where they are targeted by government or utility programs, or where there exists substantial customer demand. Correspondingly, retailers in rural areas are less likely to stock unknown or risky products.

- *Popular Attitude and Consumer Habits*. The use of unconventional technologies, such as wind generators, solar electric, solar thermal, or waste-to-energy plants may encounter resistance due to the "not-in-my-back-yard" syndrome, where communities reject the construction of some facilities in their neighborhoods because of aesthetic, health, or other concerns. Similarly, technologies or processes that require changes in established business or personal routines can encounter resistance.

[2] While some energy-efficient technologies cost more than their less efficient counterparts, the use of integrated approaches to improving building energy efficiency can lead to lower up front costs through downsizing of heating, ventilation, and air conditioning (HVAC) system components.

- *Inaccurate Price Signals*. The prices set for electricity and gas may not accurately reflect the actual costs of supplying energy at different times of the day and year. By not facing the actual costs of energy service, consumers choose levels of consumption that are suboptimal from society's perspective.

Reducing these barriers is the objective of direct state and PUC-driven DSM policies and programs. The barriers' complex and varied nature means that a successful state strategy for reducing them must itself be multi-faceted and comprehensive. The next section describes briefly the types of technical approaches available for reducing energy consumption in the residential, commercial, and industrial sectors. Sections 5.1.2 and 5.1.3 then outline the types of state policy actions that can be taken to encourage adoption of these technical approaches. Sections 5.1.4 and 5.1.5 provide additional details on approaches for reducing energy consumption in the agricultural sector and in urban areas through the use of tree-planting.

5.1.1 Technical Approaches for Improving Energy Efficiency and Reducing Energy Use

DESCRIPTION

Aggregate energy consumption is the product of millions of individual decisions on the type and level of energy service desired, the types of equipment and fuel to use to provide the desired service, the types of buildings in which we live and work, and the kinds of commercial services and manufactured products we buy. This includes, for example, the amount of energy used to produce heat, light, hot water, or manufactured products. Technical approaches for reducing greenhouse gas emissions represent energy consumers' alternatives for reducing the amount of, or altering the source of energy used to produce a desired level of energy services.

These approaches fall into three general categories: improving energy efficiency; shifting energy consumption patterns (*i.e.*, load shifting); and fuel switching. Energy-efficiency improvements can be further divided along three lines: building measures (*e.g.*, building shell measures to reduce heating/cooling requirements); equipment improvements; and process changes. These are the exact technical approaches, elaborated in more detail below, that the policies outlined in the remaining parts of this section (5.1.2 through 5.1.5) aim to promote. These measures offer significant opportunities for reducing greenhouse gas emissions. Significant energy improvements are available for addressing each of these factors.[3]

Building Shell Measures. Approaches to improve the efficiency of building shells include a wide range of building design, construction, landscaping, and retrofit actions. Major decreases in energy use can be achieved by increasing insulation levels, installing improved window technologies, orienting the building to take advantage of the sun for heating, using thermal mass for storing solar energy, and minimizing north-facing window area. Interior design can emphasize minimizing of ventilation energy requirements. While many building shell approaches are practical only during the design and construction of buildings, significant energy savings are available through shell retrofit measures designed to reduce infiltration and heat loss.

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[3] In existing residential and commercial buildings, energy use for heating and cooling accounts for around 57 percent of carbon dioxide emissions, appliances account for around 20 percent, lighting for about 14 percent, and hot water for around 9 percent (OTA, 1991).

- *Device or Equipment Measures*. These measures replace existing energy-using equipment with more efficient technologies, and are available for every energy end use at efficiencies substantially above current levels. The applicability of energy efficient equipment in any given case, however, can be limited by technical, operational or economic barriers.

- *Process Measures*. Substantial energy-efficiency gains can be achieved through changes in the processes used to produce goods and services. Processes can range from substituting an energy-efficient fax machine or electronic-mail system for air couriers to the adoption of electric arc furnaces and installation of cogeneration systems to make use of waste heat in industrial and other facilities.

- *Load Shifting*. Load shifting changes energy consumption patterns to different times of the day to reduce excess energy demand at peak hours. Load shifting does not directly increase energy consumption efficiency, but it can lead to more efficient operation and reduced emissions by energy suppliers. Electric utilities make significant use of programs to electronically cycle air conditioners during peak periods, and peak load pricing programs to shift consumption to off-peak hours, to increase the efficiency and lower the costs of power generation. The potential for emission reductions from load shifting depends on the specific fuel mix and operating characteristics of each utility.

- *Fuel Switching*. The substitution of one energy source for another often is an effective way to reduce greenhouse gas emissions. This can occur at sites that provide power, such as large electricity generating stations, or on a much smaller scale such as in the home. Substituting gas for electricity to heat water, for example, can lead to a reduction in power plant fuel consumption and emissions. Alternatively, replacing current gas technologies with very efficient electrotechnologies can produce net system reductions in energy use and emissions, even after accounting for the losses in the generation and transmission of electricity. As with load shifting, the energy and emissions reductions realized by fuel switching depend heavily on the specific situation.

Exhibit 5-5: Energy Efficient Library in North Carolina

In 1982, the town commissioners of Mt. Airy, North Carolina, planned construction of a library that consumes 70 percent less energy than a conventional building. By using clerestories (skylights where the glass is mounted perpendicular to the roof) across the top of the library, the building provides glare-free, diffuse light to all corners of the library without directly illuminating the stacks, thereby eliminating unwanted heat and glare as well as minimizing damage to the books from sunlight. As a result, the electricity used for lighting was reduced to only one-eighth of the total energy consumption for the building, as compared to the national average of about one-fourth. The building design also incorporates insulation and a zoned system of heat pumps. Although the construction cost was $88 dollars per square foot (as compared to $79 per square foot for a conventional building), the library was found to use 53 percent less energy than a conventional design. Furthermore, the library uses 90 percent less energy than the Mt. Airy City Hall, a building of comparable size.

CONSIDERATIONS

Two general factors influence whether any given technical approach is feasible. The first concerns whether an approach can be implemented in new, retrofit, and/or replacement situations. Some approaches are feasible only when a building is being constructed since they are key elements of the structure's design. Other measures are feasible whenever existing equipment is replaced due to failure, while still other options can be retrofitted at any time. Energy used for heating buildings, for example, is determined in large part by the type of building, the quality of its construction, and level of thermal integrity. Although building thermal integrity can be improved by retrofitting it with better insulation, once built, the building's basic heating and cooling requirement can seldom be changed and therefore applies for its remaining life, measured in decades.

Exhibit 5-6: Home Energy Rating System in Indiana

The Indiana Department of Commerce, Office of Energy Policy is coordinating the design and implementation of a Home Energy Rating System/ Energy Efficient Mortgage (HERS/EEM) program. The HERS/EEM mechanism will have two components. The first is a rating system that will classify new and existing homes according to their energy efficiency. This efficiency rating will provide estimates of utility costs and may include recommendations for specific energy improvements. The second component allows mortgage lenders to incorporate the lower energy bill expected in a more energy-efficient house when evaluating mortgage applications. The goal of the program is to improve the energy efficiency of Indiana homes and to allow home buyers to make better informed decisions regarding the costs of operating a home. Contract negotiations have begun with Energy Rated Homes of America to provide the rating system for this program. Once the rating tool is customized for Indiana's needs, a pilot program will be initiated in Lake and Porter Counties. Significant progress is being made in this effort because of the dedicated cooperation of Indiana's builders, lenders, real estate professionals, and utilities.

The second factor affecting the feasibility of the technical approaches listed above is that some energy-efficiency options are not compatible with existing equipment or energy service needs. Replacing electric resistance heating in a home with an efficient heat pump, for example, may be impractical if the home does not contain any duct work. Certain commercial HVAC systems are suited only to certain applications and/or climate zones, or the lighting needs of a retail store may not be compatible with the most efficient type of lighting systems available. The key to successful implementation of energy-efficiency options, therefore, is to target the selected approaches to those segments of the market in which the specific approaches are practical, feasible, and economic.

As stated above, the following sections outline policy options for instituting these technical approaches to reducing greenhouse gas emissions.

5.1.2 Direct State Actions to Promote Energy Efficiency

DESCRIPTION

Direct state actions to encourage adoption of the technical approaches described above usually fit within five categories:

- direct actions to apply these approaches in state-controlled facilities;
- technical assistance and similar efforts to support household, business, and local government efforts to reduce energy consumption;
- financial incentive or direct assistance programs, including tax credits, loans, and grants for energy-efficiency investments;
- energy-efficiency research, development, and demonstration projects; and
- enactment and enforcement of building codes and energy use standards.

CONSIDERATIONS

States historically have played an active role in promoting energy efficiency. Beginning in the mid-1970s, most states took advantage of federal funding to create energy offices to develop and implement federally-initiated programs. The federal programs generally allowed states substantial discretion in the design and implementation of programs, leading to a diversity of creative approaches to energy efficiency.

However, direct federal support for state activities dropped off substantially in the 1980s, leading to a reduction in state activity. During this time the availability of monies from petroleum violation funds, combined with a number of individual state initiatives, allowed many states to continue promotion of energy-efficiency investments.

Although the availability of funding for direct state actions may continue to be constrained, state and local governments possess a wide array of policy options to assist households and businesses to reduce energy consumption. Innovative use of these options can produce substantial energy, economic, and environmental benefits.

A critical role in this process for state and local governments is the adoption of broad energy use or energy-efficiency standards that guide building construction, often through mandatory state or local building codes. One set of standards that is often used by states as well as the federal government is that produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE is a voluntary body of professional engineers who are familiar with the technical and economic issues surrounding energy efficiency. Additionally, a series of model building codes produced periodically by the Council of American Building Officials provides guidance for state and local governments on energy-efficiency measures.

In most areas of the country, however, states and localities consider new standards and codes only as they go through a normal building standards review cycle. This can create a lag of several years between the time a new set of standards or model codes are produced and the time states and localities adopt them or integrate their recommendations, frequently delaying use of the most modern (and sometimes the most profitable, because of related energy savings) building measures. Adoption of these standards and codes is also frequently subject to high levels of political controversy due to their impact on different private and public sector stakeholders and their varying geographical applicability. To remedy the problem of states not upgrading their standards to the most energy efficient measures, EPAct strongly encourages states to adopt energy-efficiency provisions that are at least equivalent to the ASHRAE standards for commercial buildings and to the 1992 Model Energy Code for residential buildings. States including Florida, Iowa, Indiana, New York, Washington and California have been particularly aggressive in adopting and implementing energy-efficiency standards.

Promoting energy efficiency in existing buildings (as opposed to in new structures) is complicated for several additional reasons. Foremost, there have traditionally been few efficiency standards for existing buildings. ASHRAE produced the first of such standards to complement their established new building standards. In addition, some areas currently require efficiency upgrades when buildings are renovated. One Florida standard, for example, now advises that existing structures being renovated at a cost of more than fifty percent of their value must be brought into compliance with energy-efficiency codes.

Exhibit 5-7: Light-Colored Roofing in Arizona

To help offset the urban "heat island" effect, where asphalt and lack of trees raise temperatures in city areas, the city of Mesa, Arizona replaced or re-coated the roofs of four buildings with light-colored insulation board and spray styrofoam as part of an energy retrofit. Because light-colored surfaces reduce the amount of heat that a city absorbs, they can improve the energy efficiency of individual buildings. Prior to the retrofit, each of the buildings had a dark green or black roof and no insulation. The new light-colored roof will remain cooler on sunny days than a darker roof, reducing the cooling load in the upper floors of the building. Additionally, light surfaces radiate heat as effectively as dark surfaces and will radiate heat into a building. As a result, the new roofs are expected to reduce the heating and cooling load attributed to the roof by 20 to 30 percent. The estimated payback for this measure is quite long, about 20 years. However, this project was completed as part of a retrofit that included the installation of energy efficient lighting and heating, and improvements in ventilating and air conditioning (HVAC) systems, which all have much shorter paybacks. Thus, most of the savings from the entire retrofit will be realized sooner.

Besides the general need for building standards and codes, the barriers discussed earlier in this section also affect consumer willingness to improve energy efficiency in existing buildings. Overall, the residential or commercial landowners, managers, and renters who may decide whether to improve energy efficiency in buildings frequently are not aware of the benefits, believe it will be costly, or think it will interfere with their schedules and operations.

Usually, the basic incentive to upgrade the level of energy efficiency in a building is to save money. However, two distinct types of disincentives often inhibit these types of upgrades from occurring. First, tenants may feel that they will inhabit their building for short or uncertain periods of time and therefore hesitate to make investments for which they may not capture the long term benefits. Second, potential investors in energy efficiency often do not pay the electric bills and therefore do not realize the benefits. For example, a landlord is rarely concerned about his/her tenants' future electricity bills and therefore has no incentive to upgrade energy-efficiency.

Another distinct factor inhibiting efficiency upgrades in existing buildings is the slow replacement rate of existing equipment. In the residential sector, for example, most homes in the U.S. already have water heaters, refrigerators, electric lights, and central heating and/or air conditioning. The replacement rate of these items with more efficient ones generally depends on the installed appliances' expected lifetimes, which can range from five to twenty years or more.

POLICY OPTIONS

- *Develop Institutional Planning and Support Structures.* States without existing agencies to deal with energy issues may consider developing them as a means for conducting planning and analysis, administering programs, and providing support for utilities, industry, and consumers. In many states these agencies have been instrumental in facilitating energy-efficiency measures.

- *Institute Long-Range Planning*. Many states, including Iowa, Illinois, New York, Vermont, and Washington mandate energy agencies to provide assessments of state energy consumption as well as potential ways to increase efficiency, reduce energy dependence, and increase use of renewable energy resources. These plans provide valuable focal points for policy development through time and across the economic sectors that affect a state's energy consumption.

- *Facilitate Interaction Between DSM Program Sponsors and Potential Customers.* States are in a unique position to facilitate interactions between a variety of important participants and stakeholders in the energy-efficiency field. For example, states may act as the liaison between federal energy-efficiency programs and local industries and governments, or between utilities and potential commercial or industrial energy-efficiency clients. The "Super Good Cents" program in the Pacific Northwest, for example, is a state-utility partnership that involves providing technical information and training, as well as rebates to consumers for energy-efficiency investments in their homes.

- In addition, state governments can lead collaborative efforts involving government agencies, utilities, energy service companies, customers, and advocacy groups to develop consensus approaches to energy-efficiency policies and programs.

- *Rationalize State Tax Policy*. Although practice varies from state to state, tax policies often favor energy consumption over energy efficiency. In some states, purchases of gas and electricity are exempted from states taxes, while energy-efficiency investments (more efficient equipment, insulation, etc.) are not. At a minimum, tax policy may cease to favor consumption over efficiency, but may further serve to discourage inefficient consumption.

- *Provide Information and Education*. States can gather and disseminate information (often working with utilities) on the energy and financial implications of energy-efficiency projects in certain types of buildings and facilities and promote research, development, and demonstration projects. Through their university systems states may also promote energy-efficiency training in professional planning and urban design programs.

- *Take Direct Action to Reduce Energy Consumption in State Facilities*. States can reduce energy consumption on their own properties, including schools and low-income housing projects. Iowa, for example, undertook an energy-efficiency improvement program designed to make all of its public school buildings energy efficient by 1995. Such programs may involve retrofitting existing state facilities, changing state building and procurement practices to require energy-efficiency investments, and modifying state building design requirements. For example, Florida has initiated a broad effort to reduce energy consumption in state facilities by 30 percent within three years. The state also plans to use this effort as a model for local governments and the private sector.

- *Establish and Enforce Efficiency Standards and Codes*. States may wish to encourage more integrated and aggressive approaches to promoting energy efficiency in buildings by supporting and strengthening disparate and outdated building codes. In addition, states should develop mechanisms for agencies to enforce the codes they adopt. An initiative in Florida, for example, requires construction agencies to disclose the material content of their buildings to building inspectors and to the buyer; this establishes a stronger feedback loop and trail of liability if buildings are not built to energy-efficiency specifications, providing incentives for contractors to adhere strictly to the codes. EPAct encourages states to adopt energy-efficiency provisions at least equal to ASHRAE standards for commercial buildings and the 1992 model Energy Code from the Council of American Building Officials for residential structures.

- *Demonstrate Building Efficiency Measures and Facilitate Energy-Efficiency Programs.* States are uniquely situated to initiate energy-efficiency demonstration projects in buildings (often using their own facilities) and to publicize resulting information on energy and cost savings. Similarly, states are often well-situated to coordinate interactions between landlords and tenants, especially in the commercial sector, in order to facilitate efficiency improvements in existing buildings. Programs to achieve these goals can include innovative approaches such as setting minimum efficiency standards for rental properties or developing shared savings programs where landlords and tenants both benefit from energy-efficiency investments.

- *Provide Financial Incentives for Efficiency Improvements*. States can provide financial incentives for accelerating equipment replacement rates through tax credits or low interest loans on efficiency improvements, by taxing inefficient appliances and equipment, or by working with utilities to sponsor rebate programs that induce consumers to purchase efficient products. Hundreds of these types of programs exist throughout the country. For example, the State of Oregon offers a 35 percent Business Energy Tax Credit and a Small Scale Energy Loan Program. Similar programs are supported by the Indiana State Energy Office through innovative public and private partnerships.

5.1.3 Policies to Promote Energy Efficiency, Renewable Energy, and Carbon Offsets

DESCRIPTION

In the recent past, state energy officials and utility regulators have promoted measures to increase energy efficiency, in order to reduce the energy costs borne by state residents. State officials have worked with electric and gas utilities to promote energy efficiency in programs termed either demand-side management (DSM) or integrated resource planning (IRP).

With deregulation of the electric utility sector, the opportunities available to state officials to promote energy efficiency are changing. Once electricity generation is deregulated in a state, prices will be set by market forces. State officials will no longer regulate electricity prices, and thus will not have the opportunity to ensure that utilities employ conservation measures where these are less costly than new generation. Nor will state officials have much direct influence over new suppliers of electricity that enter the market after deregulation.

At the same time, however, deregulation will provide opportunities for states to indirectly influence the markets for energy and energy conservation. These opportunities can be used to promote energy-efficiency and fuels with relatively low GHG emissions.

CONSIDERATIONS

Electric and natural gas service reaches virtually every household, and these energy sources supply the majority of energy used by households and businesses. Policies that serve to reduce emissions from the use of electricity and natural gas can have a major influence on a state's level of greenhouse gas emissions.

POLICY OPTIONS

Chapter 6 discusses five policy options for reducing GHG emissions through energy conservation, renewable energy, and carbon offsets in the electric utility sector. The following options are described in Section 6.1:

- *Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"*
- *Institute a "Social Benefits" Charge or a Carbon Tax on Electricity Generation*
- *Promote Voluntary Adoption of Energy-Saving Technologies*
- *Establish or Support Carbon Offset Programs*
- *Support Emission Trading Programs*

As utility deregulation proceeds, states may consider one or more of these policy options to reduce greenhouse gases in the energy sector; many of these options can reduce energy costs for state residents.

5.1.4 Conserve Energy Through Improved Industrial, Agricultural, and Municipal Waste Management Processes

The preceding subsections have outlined technical approaches for improving energy efficiency, and described general policy approaches -- *Direct State Action* and *PUC Policies* -- for encouraging these actions. Most of the technical approaches and policy options apply equally to the residential, commercial, and industrial sectors. However, the industrial sector presents a challenge to policy-makers because of its diversity, the relative magnitudes of the savings available from individual industrial facilities, and the investment costs required to achieve these savings. The agricultural sector presents challenges as well because many of the policy options exercised in other sectors are not applicable to agriculture. Perhaps more important, PUC-directed utility DSM programs may not be available to rural customers who are served by rural electric cooperatives. In the municipal solid waste management sector, decisions are typically made at the local government level. For these reasons, industrial, agricultural, and municipal waste management policy options are considered apart from the previous discussion.

These sectors use large amounts of energy to produce goods, including heavy industrial products, consumer products (which may result in generation of MSW), and food. Many industrial and manufacturing technologies for extracting, refining, and processing raw materials and for building a variety of finished goods are extremely energy-intensive. Similarly, modern farms grow, harvest, and refine crops, maintain livestock, and process meat and dairy products using machinery and equipment that draw large amounts of energy. There is enormous potential for conserving energy in these sectors by utilizing energy efficient machinery and processes, and by increasing source reduction and recycling (because typically less energy is used when recycled inputs are used in place of virgin inputs). Actions to reduce energy use may also bring significant ancillary benefits, like reduced costs and improved productivity, and therefore general economic stimulation in the regions where the industries and farms are located.

Because they span most types of industries, manufacturers, and farms, the range of approaches for reducing energy consumption in these sectors is too situation-specific to present here. The general energy conservation principle is that these energy consumers can either improve their machinery and technologies to utilize less energy, or they can use the by-products (sometimes just heat) from their operations to produce energy on-site. The latter process often utilizes formerly wasted resources and supplants the need to draw so much power from traditional sources. Section 5.2 elaborates on these types of renewable energy production processes.

Examples of the first category of energy efficient processes include use of variable speed motors that adjust continuously to meet work load demand, thus saving energy when work loads are light, and the use of infrared rather than more energy-intensive thermal processes for drying grain or for drying fresh paint on consumer products.

Several specific constraints, however, may inhibit efforts to improve energy efficiency. For example, besides the general barriers that apply to adoption of all energy efficient technologies, which the beginning of this section discusses, a relatively long time period is usually required for the replacement of industrial equipment. Most energy-intensive industrial processes are capital-intensive and the rate of equipment turnover is often measured in decades. Additionally, the diversity of technologies and operations utilized in these sectors can sometimes make it difficult to apply one type of efficient technology in distinct settings.

POLICY OPTIONS

Programs to encourage energy efficiency and conservation through improved industrial, agricultural, and municipal solid waste management processes can be designed in two ways. First, they can concentrate on specific categories of businesses, like steel producers, small engine manufacturers, or dairy farms. Doing so requires understanding the economic and technical environment surrounding the particular sector being addressed, including how that sector uses energy, available energy-efficiency technologies in that sector, and how these technologies will affect product quality and production. By addressing the distinct needs of each type of business being targeted, states can enhance the prospects for success in reducing energy consumption. States including North Carolina, Louisiana, and New York have developed effective programs of this type.

The second approach is to promote energy efficiency across all categories of industries or farms, or in the cross-cutting area of municipal waste management, providing broad education or incentives to encourage innovation and energy efficiency in as many areas as possible. Specific policy options are listed below.

- *Support Research and Provide Direct Assistance Targeted at Specific Businesses or Sectors.* States, often through energy agencies, can select particular energy-intensive industries to assist with research, financial support, and technical assistance. For example, the Louisiana State Energy Office works with the state's aquaculture industry to develop innovative engineering approaches for increasing that industry's energy efficiency and simultaneously enhancing their economic productivity.

- *Sponsor Technology Demonstration Projects*. States, often working with leading firms in a targeted industry, may demonstrate the potential for using new energy-efficiency technologies to everyone in that industry. The demonstrations can both provide good public relations and prove the technology's success with an industry leader.

- *Provide Broad Incentives for Energy-Efficiency Research and Development.* Broad programs to solicit innovative ideas on energy efficiency from all sectors can provide incentives for research and development in areas that state programs will never directly address. These incentives may be research grants, energy-efficiency loans, or direct financial or publicity rewards for independent innovation.

- *Provide Direct Financial Incentives for Energy-Efficiency Investments.* Similar to subsidizing energy efficiency in buildings and in other sectors, financial assistance, low interest loans, and rebate programs targeted at specific energy-efficiency investments can promote technological conversions. For example, the Bonneville Power Administration in the Pacific Northwest is currently working with its industrial customers to encourage energy conservation through equipment rebate programs (Washington, 1993). Current program savings have consistently met or exceeded the Power Administration's goals. These rebates are often customized to meet the distinct needs of particular customers and situations, in contrast to standardized technology-based rebates that apply in other sectors.

5.1.5 Promote Urban Tree Planting

Another mechanism for reducing demand for energy is through strategic planting of trees and shrubbery in urban areas. This type of program, though potentially significant, is often not considered in traditional demand-side management programs.

Landscaping offers the potential to reduce energy needs related to heating and cooling in two ways. First, by providing shade and lowering wind speeds, vegetation, such as trees, shrubs, and vines, can protect individual homes and commercial buildings from the sun's heat in the summer and cold winds in the winter. Second, collective tree planting provides indirect carbon reduction benefits; evapotranspiration (the process by which plants release water vapor into warm air) from trees and shrubs can reduce ambient temperatures and energy use for entire neighborhoods during hot summer months. Urban tree planting can also generate direct carbon benefits. Because half the dry weight of wood is carbon, as trees add mass to trunks, limbs, and roots, carbon is stored in relatively long-lived structures instead of being released to the atmosphere. Thus, programs to support urban tree planting can help reduce greenhouse gas emissions in a variety of ways.

Urban tree planting also provides a number of non-carbon benefits, such as improving air quality, improving aesthetics, providing wildlife habitat, improving property values, and reducing noise. Trees may also reduce runoff, prevent soil erosion, and slow the buildup of peak water flows during an intensive rainfall. Residential planting can also promote awareness of the potential contribution that the general public may make to reducing U.S. emissions of carbon dioxide. Available data indicate that over half of the available tree spaces in American cities are empty. At the same time, a variety of constraints can inhibit tree planting programs. These commonly include water restrictions in some areas and the fact that compacted soil and urban irritants such as salt can inhibit a tree's natural growth. Additionally, improperly placed trees can reduce solar heat in the winter.

With careful planning, however, tree planting programs can be highly successful. In Minnesota, for example, the Twin Cities Trees Trust has blended the goal of employing disadvantaged adults with environmental improvement in the form of urban tree planting and landscape construction (Minnesota, 1991).[4] The Sacramento Municipal Utility District in California has contributed over a million dollars annually to the Sacramento Tree Foundation for tree planting activities. Grants from the County and City of Sacramento, together with an Urban Forestry Grant from the California Department of Forestry, also support Trees for Public Places, a community tree planting program. At the national level, Cool Communities, sponsored by DOE, encourages the planting of shade trees to improve energy efficiency, while simultaneously sequestering carbon. The Cool Communities program has been tested, and found effective, in Tucson, AZ; Dade County, FL; Atlanta, GA; Springfield IL; Frederick, MD; Tulsa, OK; Austin, TX; and Davis-Monatham Air Force Base, AZ. It is currently being further expanded under the CCAP.

POLICY OPTIONS

State programs to support urban tree planting often involve providing technical assistance, grants, and educational services to local communities and private organizations. More direct programs may target residences and business. Specific policy options include:

- *Provide Institutional Support to Communities.* Technical assistance can aid communities and utilities in designing residential tree planting programs and assessing their energy and carbon benefits. This is especially helpful in areas where localities do not have access to the technical knowledge and resources necessary to coordinate programs.

- *Provide Financial Incentives to Organizations and Individuals.* States can encourage private and local tree planting programs through cost-sharing or direct payments to homeowners or utilities or through direct program financing for local organizations. Direct or guaranteed loans to encourage tree planting may also be successful. Utility demand-side management programs in California directly subsidize residential and commercial tree planting activities.

- *Support Research on the Effects of Tree Planting.* Support for research and development or pilot testing, in the form of direct technical assistance, grants, tax incentives, or loans, can help answer some of the outstanding questions in this area pertaining to the potential benefits and feasibility of tree planting programs in different regions. For example, state grants may encourage non-profit organizations or university groups to investigate the strategic placement of trees in cities or neighborhoods to maximize year-round energy savings.

- *Regulate Tree Planting.* Typically the purview of localities, landscape ordinances requiring tree plantings with new construction have been used in many cities.

5.2 GREENHOUSE GASES FROM ENERGY PRODUCTION: SUPPLY SIDE MEASURES

As described in Section 5.1, measures to decrease carbon dioxide emissions from the energy sector may focus on either reducing energy consumption or reducing emissions during electricity production. This section addresses the electricity production category, highlighting the critical role of utilities and independent power producers. Section 5.1 addressed the consumption category while Chapter 6 combines these issues in a discussion of the economic framework that shapes the energy market in the U.S. While

[4] Minnesota has researched and produced a document entitled *Carbon Dioxide Budgets in Minnesota and Recommendations on Reducing New Emissions with Trees* that specifically addresses reducing carbon dioxide emissions and energy demand through tree planting.

treated separately for ease of presentation, these three sections of the document are closely connected and should be considered together.

Several federal statutes affect the level of greenhouse gas emissions from electricity production including the Public Utilities Regulatory Policy Act (PURPA), the Public Utilities Holding Company Act (PUHCA), and the EPAct. Under PURPA, the federal government and state governments can encourage efficiency among power producers and can encourage transitions to modes of power production that result in lower greenhouse gas emissions, including use of renewable fuel sources. States can also affect greenhouse gas emissions in the power supply sector through their jurisdiction pertaining to environmental protection, as well as through regulation of powerplant siting and certification. States have some jurisdiction in controlling natural resource use, for example, upon which the power supply sector relies heavily, and in protecting wildlife and wildlands, which some utility emissions or power development programs may threaten.

This section discusses approaches to reducing emissions from three types of energy producers: utilities, independent power producers that sell the energy they produce (mostly to utilities), and industrial and agricultural facilities that use their energy on-site to support their own operations. Although many policies to promote emission reductions will affect all three of these producer categories, resulting in some overlap in the information presented below, the distinction between the three remains useful because the size and scale of their operations varies significantly and each faces a distinct set of potential motivations for reducing emissions.

There are three primary actions each of the three types of producers can pursue for reducing emissions, depending on the nature of their current operations:

- *Transition Away from High Carbon Generating Technologies and Fuels.* In a greenhouse gas context, this frequently means utilizing natural gas, hydroelectric, or nuclear energy instead of coal or oil. Universal constraints to switching to natural gas include the need for producers to have access to this fuel, which may be limited by infrastructural or legal constraints in some regions, the relative price volatility of gas, and questions regarding deliverability. Other constraints inhibit the large-scale non-carbon alternatives. Hydroelectric power development, for example, is often limited by environmental concerns such as ecosystem damage through flooding and disruption of water supplies, and nuclear power production is constrained by public safety and environmental concerns, as well as the cost of nuclear units and perceived financial risks. No new nuclear plants have been commissioned in the United States for several years.

- *Use Renewable and Alternative Energy Sources*. Alternative energy sources consist of non-fossil fuel based power generating technologies and processes, including biomass, waste heat used for on-site cogeneration, methane from non-traditional sources, wind, geothermal heat and pressure, solar thermal and solar photovoltaic processes, and tidal currents.[5] Initial installation costs can create constraints and vary significantly among sources; in many cases these costs limit the ability to compete with fossil fuels. Research and development on technologies to utilize many of these sources is gradually enhancing their cost-effectiveness.

- *Reduce Emissions Regardless of Fuel Type Through Technology and Process Upgrades.* Using the most efficient electricity generating technologies and processes can minimize the average

[5] Chapter 6 examines biomass energy programs in more detail, describing how agricultural and forest crops can be used to generate power or to produce liquid, gaseous, and solid fuels for other purposes.

quantity of greenhouse gases emitted per unit of electricity produced. This can be achieved either by operating existing equipment at optimal rates of generating efficiency (which means attaining the highest feasible energy output per unit of fuel input), or by installing new technologies that offer higher levels of power generating efficiency than are currently available. The most frequent constraints on these processes are equipment investment costs and fluctuations in energy demand that make it difficult to maintain optimal generating efficiency. In addition, significant savings may become available through reductions in transmission and distribution losses as new technologies are adopted, as well as through use of cogeneration and district heating.

The sections below discuss each of these three mechanisms as they apply to the electricity generation sector, and to on-site energy producers/consumers.

Alternative policies to promote emission reductions may affect not only the different types of power producers but also the time frames within which certain approaches are implemented and their greenhouse gas reduction benefits accrue. Some approaches are feasible and offer emission reductions immediately, like capturing and utilizing methane at coal mines and landfill sites, while others may take many years to implement, as with certain renewables, whose costs must come down before they are economical. While long term projects in the energy supply sector often require large-scale capital conversion, technological innovation, and infrastructure development, they also offer the highest potential magnitude of emission reductions of all greenhouse gas sources.

Common constraints or barriers can inhibit approaches to reducing emissions during power generation across all types of producers. These include high initial capital costs for new technologies, lengthy government permitting processes for new or modified power production, and regulatory limitations on the size or extent of power producing activities. Other barriers include limited access to transmission lines for remote energy sources (for example, wind or geothermal) and financial risks which require rates of return higher than for traditional power sources. Finally, tradeoffs with other state policy objectives (for example, promoting economic stability by supporting utilities or promoting aesthetic interests where extensive solar or wind power generating facilities are feasible) may also impede emission reductions. The policy options outlined under the following technical approaches address these barriers.

5.2.1 Reduce Greenhouse Gas Emissions from Electricity Generation

DESCRIPTION

The electricity generating sector can help reduce greenhouse gas emissions by improving the efficiency of electricity generation or by generating power using low-emission or no-emission technologies. As mentioned above, because the electricity generating sector uses substantial amounts of fossil fuel, there are opportunities for significant GHG reductions in this sector.

CONSIDERATIONS

Improving processes directly at electricity generating plants can include two types of actions:

- *Switching to low-emission fuels and generating technologies.* In the near term, the greatest opportunities for reducing emissions are likely to involve utilizing natural gas, the fossil fuel with the lowest carbon content per unit of energy.[6] Natural gas can be converted to electricity at high efficiency, using new combined cycle gas turbines. (Extensive literature is available on fuel-switching and efficient technologies for electricity generation.) Under utility deregulation, market forces will determine the extent to which such low-carbon technologies will substitute for coal- or oil-burning generators. Section 6.1 discusses potential policies that states could implement to favor such technologies.

- *Switching to zero-emission technologies.* When renewable energy sources (including photovoltaics, biomass fuels, and wind) are used for electricity generation, no greenhouse gases are emitted. (The carbon dioxide from biomass fuels is not counted because it is biogenic.) Although costs of generating electricity from renewable sources is currently higher than costs for fossil fuels, the costs of photovoltaics and other renewables are declining. Section 6.1 discusses potential policies that states could implement to favor renewables.

- *Improving the efficiency with which energy is produced using existing equipment and facilities.* Technological innovations may offer the opportunity to improve generating efficiency beyond commonly attained levels.

A state may wish to examine the greenhouse gas emissions (and perhaps other pollution) associated with producing electricity, and reflect these "externality" costs in the price of electricity. Section 6.1 discusses two possible approaches -- a "societal benefits" charge or a carbon tax on electricity generation.

Policies designed to reduce emissions from electricity generation should account for several additional issues. Foremost, the actions discussed above to reduce greenhouse gas emissions generally support other environmental objectives as well, such as producing less particulate air pollutants per unit of energy produced. However, switching away from high carbon fuels, especially coal, will also have significant impacts on economies in certain regions of the country that are rich in these resources. Additionally, limited infrastructure for supplying fuels like natural gas in some areas may inhibit the use of these fuels for large scale power generation.

POLICY OPTIONS

Policies to reduce greenhouse gas emissions from electricity generation will ideally (1) promote demand-side management to mitigate the need for new power sources; (2) support alternative low-carbon energy sources to meet new power needs whenever possible; and (3) encourage the transition from existing high-emission fuels and technologies to low-carbon options. Specific options for pursuing these objectives, which are discussed in Section 6.1, include:

- *Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"*
- *Institute a "Social Benefits" Charge or a Carbon Tax on Electricity Generation*
- *Promote Voluntary Adoption of Energy-Saving Technologies*
- *Establish or Support Carbon Offset Programs*
- *Support Emission Trading Programs*

[6] While natural gas offers the lowest carbon emission rates of the various fossil fuels used for producing electricity, switching to *any* source with lower carbon content than the fuels currently used will yield greenhouse gas benefits. In some situations, for example, this could suggest switching from coal to oil rather than converting to natural gas, although this choice may not be desirable for other reasons, such as national security and trade balance concerns.

In addition, states may wish to consider providing subsidies and marketing support for renewable energy:

- *Provide Direct Incentives for Alternative Energy Development.* States can promote renewable energy development through investment tax credits, equipment subsidies, low-interest loans, copayments with utilities on energy produced from alternative sources, and other incentive programs.

- *Provide Information, Education, and Technical Assistance to Support Alternative Energy Development.* States can conduct demonstration projects, do financial analyses, and provide information about alternative processes to the potential investment community. For particular projects, states may also be able to provide direct services such as financial assessment or technology upgrade audits.

5.2.2 Reduce Emissions Through On-Site Power Production

Various industrial and agricultural facilities can help reduce net greenhouse gas emissions and save money by utilizing on-site resources to meet their energy needs. Coal mines can capture methane and use it to generate electricity for their own use, for example, and dairy farms may use methane from livestock wastes as an energy source. In essence, power consumers in these situations become small scale power producers. They reduce greenhouse gas emissions by meeting part of their energy needs that would traditionally have been met by utilities and, in many circumstances, by utilizing excess methane that would otherwise have contributed directly to greenhouse gas emissions.[7]

Two types of energy may be generated through on-site processes: thermal heat and electricity. Where a site requires thermal energy, cogeneration of both thermal energy and electricity should be considered, because cogeneration is a highly efficient process.

CONSIDERATIONS

These actions can be considered as either production side emission reduction measures or consumption side energy-efficiency measures. They reflect distinct characteristics of each, including demand-side barriers to energy efficiency and supply side constraints for renewable energy.

Additional information on specific opportunities for using methane for on-site energy production is presented in Sections 5.5 through 5.9. Policy-makers should investigate the opportunity for promoting these processes at both existing and new facilities, because the incentive and support structures for retrofitting existing facilities may vary from those for initial investment.

POLICY OPTIONS

Many of the same policies listed in Section 5.2.1 will apply to on-site power producers. In addition, states can:

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[7] Methane is an important greenhouse gas. Biomass wastes contribute to methane and/or carbon dioxide emissions when they are burned for disposal, left to decompose, or placed in landfills.

- *Provide Direct Assistance for Equipment and Facility Conversion.* States may conduct technological and financial analyses for specific industrial facilities in order to demonstrate the value of cogeneration and similar practices. States may also be able to provide ongoing technical support to enhance industry confidence in new processes, and can initiate the type of financial support through taxes and subsidies listed in the previous section.

- *Establish Programs and Regulations to Reduce Risk to Firms.* States may guarantee financial support if new processes do not function as expected and may require utilities to provide backup power to industrial facilities, like coal mines, if those facilities' on-site sources do not meet their energy needs. Without these provisions utilities may have incentives to distort prices or restrict power access to customers who are considering producing their own energy.

5.3 GREENHOUSE GASES FROM THE TRANSPORTATION SECTOR

Carbon dioxide (CO_2) is the main byproduct resulting from combustion of gasoline and other petroleum-based fuels used by the transportation sector. Carbon dioxide emissions are directly proportional to the quantity of fuel consumed: burning a gallon of gasoline releases approximately 20 pounds of carbon dioxide into the air (OTA, 1991). In addition, the extraction, processing, transfer, and combustion of fossil fuels produce other greenhouse gases, lead, and other pollutants, and contribute to acid rain and urban ozone precursors.[8]

The transportation sector consists of highway and off-highway vehicles, marine vessels, locomotives, and aircraft. Highway vehicles include automobiles and light-duty vans and trucks up to 6,000 pounds in weight, light-duty trucks between 6,000 and 8,500 pounds in weight, heavy-duty trucks and buses, and motorcycles. Off-highway vehicles include farm tractors and machinery, construction equipment, snowmobiles, and motorcycles. This section focuses on options to reduce emissions from the highway vehicles fleet.

Activity to the transportation sector from all these vehicle categories is fundamentally a product of the demand for mobility of either people or goods and services in our society. Traditionally, as this demand for mobility increases, so do related emissions of carbon dioxide and other pollutants. Policies to reduce emissions in this sector, therefore, can be targeted either at reducing the demand for mobility in general, or reducing emissions at current or increasing levels of transportation activity. Both of these approaches are referenced throughout this section. In addition, Chapter 6 discusses the potential for reducing emission from the transportation sector through land use change and city and rural planning measures (see section 6.5).

It is important to note that this section provides only a brief introduction to transportation policy.[9] In this complex field, in general, carbon dioxide emissions from the transportation sector are currently not

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[8] These other pollutants include: methane, carbon monoxide, nitrous oxide, non-methane hydrocarbons, oxides of nitrogen and sulfur, and particulate matter. Nationwide, transportation is responsible for 70 percent of carbon monoxide, 40 percent of volatile organic compounds, 40 percent of nitrogen oxides, and 35 percent of lead, particulates, and nitrous oxide. While these other gases from the transportation sector are also considered to be greenhouse gases, they are not thought to be major contributors relative to the carbon dioxide emissions; and, unlike carbon dioxide, some can be partially mitigated through the application of emission controls (NAS, 1991).

[9] For a more comprehensive overview of the environmental implications of transportation measures, see Kessler and Schroeer, 1993 and OTA, 1994. (Note: OTA gives an overview of the U.S. transportation system and options to increase energy-efficiency within this sector.)

regulated, while regulation of other transportation-related emissions and fuel consumption standards have traditionally fallen under federal jurisdiction. Criteria pollutant emissions are controlled through the Clean Air Act (which is implemented at the state level through State Implementation Plans), while light-duty vehicle fuel efficiency is regulated through Corporate Average Fuel Economy (CAFE) standards as established in the 1975 Energy Policy and Conservation Act. Some states, notably California and those in the New England region, have sought additional improvements in their urban air quality through various measures to limit vehicle emissions (South Coast, 1991; New England, 1990). These measures include transportation control and air emissions standards that supersede existing federal standards. The South Coast Air Quality Management District's Air Quality Management Plan for the Los Angeles Basin, discussed in Chapter 2, represents an example of such a comprehensive plan for regional emission reductions.

Technical approaches for reducing greenhouse gas emissions from the transportation sector include reducing vehicle miles traveled, reducing emissions per mile traveled, and using alternative fuels. The remainder of this section discusses these three approaches.

5.3.1 Reduce Vehicle Miles Traveled (VMT)

DESCRIPTION

Reducing total vehicle miles traveled involves decreasing the overall need or desire for driving, replacing single-occupancy driving with alternatives such as mass transit or car pools, or shortening the time and/or the distance required for each trip. Collectively, these are known as transportation control measures (TCM). Reducing vehicle miles traveled in other transportation categories, such as heavy vehicles transport and trains, also involves switching to alternative modes of transportation or combining modes, increasing load factors (for example, reducing empty or partial-load trips for busses and shipping of products), reducing travel needs, and shortening of travel time and/or travel distances.

CONSIDERATIONS

The issues associated with VMT reduction measures that influence how effective these measures will be in attaining emissions reductions include:

- *Infrastructure Issues*. Many regions, especially in the west and south, have less developed mass transit systems. Additionally, transportation control measures might not be feasible for states that are predominantly rural.

- *Financial Issues*. Many cities and states currently do not have the financial means to implement extensive transportation control measures, urban light rail systems, or intercity high speed rail. While some measures can be cost-effective by reducing the time workers spend in traffic,[10] or reducing the energy consumed per-passenger, implementing a transportation control measures package requires significant advance planning and preparation, and may also require extensive commitment from governments with limited resources.

[10] For example, the City of Denver, CO was able to reduce up to 40 percent of commuters' commuting time by instituting high occupancy vehicle lanes and other transportation control measures.

- *Institutional Issues*. Many Americans simply prefer driving over any other form of transportation or prefer goods which must be shipped long distances. Switching to alternative transportation modes or reducing VMT in other ways may require lifestyle adjustments.

Experience from existing transportation control programs to reduce air pollution in various cities offers insights into some ways these constraints can be addressed. These general insights should be considered during the implementation of all types of policies. Foremost:

- *Transportation control measures are often most effective when multiple complementary measures are implemented simultaneously as a single package*. This may include, for example, development of employee ride-share incentives, construction of high-occupancy vehicle lanes (carpool lanes), and increases in rates charged for parking.

- *Transportation control programs achieve larger emission reductions when they are coordinated throughout a region and over an extended period of time.*

- *Transportation control programs function best if implemented locally, so that measures can be tailored to traffic patterns, infrastructure, and zoning ordinances in each individual area*. In all situations, critical characteristics that transportation control programs need to consider prior to new program implementation include factors such as population and employment groupings, highway capacities and congestion levels, and major transportation routes and alternatives (OTA, 1991). Chapter 6 presents information on additional land use and city and regional planning considerations as they affect transportation control measures to reduce VMT.

An additional analytic consideration relating to transportation control efforts is that in many areas there is latent demand for access to primary transportation corridors. This implies that as congestion decreases because of the transportation control measures, some people who were discouraged from driving before due to congestion may begin to use their cars as single-occupants, thus negatively impacting emissions reduction efforts.

POLICY OPTIONS

Options for reducing transportation demand, especially for reducing single-occupancy driving, include:

- *Information and education programs*. States may implement programs to encourage alternatives to driving, including public education campaigns and various types of demonstration or pilot projects. For example, many states support campaigns to promote the benefits of high-occupancy vehicles lanes, ride sharing, and mass transit. In addition, states can work directly with employers to develop new VMT reducing programs. Demonstrating to employers the multiple benefits of offering employees a choice of cash rather than subsidized parking spaces, for example, can lead to decreased employee driving, increased use of mass transit, and therefore reduced carbon dioxide emissions. California has enacted legislation requiring some businesses to pursue this type of program (South Coast, 1991).

- *Institutional support programs*. States may also improve mass transit systems, high occupancy vehicle lanes (HOV), mass transit lanes, and enhanced traffic management systems such as synchronization of traffic signals. Virginia, for example, has instituted HOV lanes on much of its highway system in Northern Virginia as part of its traffic control effort. Similarly, the Connecticut Department of Transportation has helped to establish nearly 12,000 car pools and 180 van pools since 1980, saving an estimated nine million gallons of gasoline yearly.

- *Incentives to businesses and employers*. These include financial incentives (tax breaks or low interest loans) for businesses to initiate car and van pools and encouragement to alter or stagger work schedules and work modes. This may include establishing four-day work weeks or tele-commuting where employees work from their homes or other non-centralized locations, thus mitigating the need for travel to work. A pilot tele-commuting program involving 134 Arizona state employees, for example, reduced an estimated 97,078 commuting miles and saved over $10,000 in gasoline and other costs in a six-month period, and is being recommended for expansion (NGA, 1991).

- *Incentives to transportation consumers*. These include incentives to use mass transit and bicycling or walking, parking management (higher parking fees and/or elimination of subsidized parking), congestion pricing (tolls on heavily traveled roads during peak periods), auto use restriction (higher registration and license fees), and increased gasoline and road taxes. One example is the Federal government's monthly cash allowance for its employees within the District of Columbia metropolitan area who use public transportation.

- *Direct state action*. States and cities may alter local institutional guidelines and regulations that affect transportation. One of the primary opportunities in this area is to zone urban or central areas to exclude expansive development of areas for parking, so that commuters have additional incentive to car-pool or use mass transit. This approach, of course, depends on the ready availability of the low-emission transportation alternatives to single-occupancy vehicles. In a related measure, many state and city laws restrict private transportation system development to taxi cab services. Loosening these restrictions, if in conjunction with other complementary actions, may result in the development of alternative transport systems such as the van services that are allowed for commuting between many urban centers and nearby airports.

Exhibit 5-8: Automated Traffic Signal Controls in Missouri

To move traffic more efficiently in two of the state's major metropolitan areas, the Missouri Department of Natural Resources' Division of Energy granted $560,000 to the Missouri Highway and Transportation Department to install automated traffic signals. The signal control system continually monitors traffic and automatically adjusts signal timing for optimum operation and traffic flow, greatly reducing fuel consumption and travel time for motorists. Each control system is located along a main corridor to allow the bulk of motorists to move efficiently. One system was installed in Kansas City; the other near St. Louis.

In Kansas City, the automated traffic signals have reduced fuel consumption by 87,000 gallons per year, reduced the number of stops by vehicles by 16 million per year, and increased average traffic speeds such that annual motorist travel time was reduced by 120,000 hours. Similarly, in St. Louis fuel consumption has been reduced by 353,000 gallons per year, the annual number of stops has been reduced by almost 33 million, and average traffic speeds have increased to reduce annual travel time for motorists by 336,000 hours. All of these factors reduce carbon dioxide emissions.

- *Other policy options*. Additional options to reduce vehicle miles traveled include instituting auto insurance reforms to reflect the costs of driving (pay-as-you-drive auto insurance, for example) and promoting freight transportation system least-cost planning and/or imposing a load-weight-distance tax on heavy trucks to make trucking more expensive and encourage other less energy intensive modes of freight transport, such as rail. Longer term measures for VMT reduction include urban light rail development, intercity high-speed rail, and integrated and inter-modal transport systems.

As mentioned above, most of these transportation control measures function best when implemented in packages so that they support and reinforce each other.

5.3.2 Reduce Emissions per Mile Traveled

DESCRIPTION

Lowering emissions per vehicle per mile involves either improving the fuel efficiency of one mode of transportation (such as automobiles or freight trucks) or substituting with a more efficient mode (such as using trains rather than trucks). Carbon dioxide emissions are linked directly to fuel efficiency. While vehicle fuel efficiency standards historically fall under the federal government's purview, states can play a role in maintaining or improving the efficiency of the existing fleet by accelerating the replacement of less efficient vehicles with less polluting and more efficient ones. Poor system integration between transportation modes is often the cause for higher energy consumption as well as lengthy delivery times for freight transport. Therefore, encouraging the inter-modal substitution of transportation mechanisms, such as using trains or ships for long distance freight and trucks for local distribution, can also act to promote efficiency.

CONSIDERATIONS

Emission reductions from gains in fleet efficiency can take longer to realize than the gains achievable through transportation control measures described in the previous section. Improving fleet efficiency is dependent on the vehicle replacement rate. The most promising programs, therefore, might specifically target high emitting vehicles, such as light duty trucks or older, less fuel efficient automobiles.

Various institutional issues also affect efforts to increase efficiency. A primary one is behavioral: people maintain well-established habits and preferences. Customers prefer vehicles with amenities and powerful acceleration, for example, while vehicles with higher efficiency often are associated with a lack of amenities, slow acceleration, or certain safety concerns.

The two most significant technological barriers to the propagation of fuel efficient technologies in vehicle engines are reliability and availability. Generally, technologies to increase fuel efficiency also increase the degree of technological complexity and often require a higher level of maintenance and support. As with any newly introduced technology, qualified technicians and/or replacement components may not be widely available, especially in rural areas. Additionally, policy-makers should consider that current and future mandated safety and smog control devices often counteract fuel efficiency gains, impeding carbon dioxide emission reductions. Decisions on efficiency will have to balance these alternative benefits.

POLICY OPTIONS

- *Public information programs*. States may work with industry and other groups to educate consumers on the multiple benefits of fuel efficiency. This may include campaigns to stimulate demand for more fuel efficient vehicles and educate people on optimal driving practices. For example, states may consider expanding the EPA's current mileage rating system for new cars to apply to used vehicles as well and to include additional information such as estimated yearly fuel cost.

- *Incentives to vehicle users*. These include fuel efficiency purchase incentives ("feebates" or "gas guzzler" taxes, for example) and registration fees pegged to vehicle fuel efficiency, gross weight, engine horsepower, or emissions control equipment. Other innovative measures, such as programs to retire older automobiles in some areas, including Southern California and Northern Virginia, have proven to be economic on the basis of air quality improvements alone.

- *Wide-scale transportation planning*. States can support wide-scale transportation planning, including supporting on-going research on transportation efficiency and participating in federal and regional dialogues on fuel economy requirements. Connecticut, for example, has recognized and addressed the potential for traffic congestion and pollution from population growth and increased vehicle traffic through innovative pubic and private research partnerships since 1980. This type of planning most often results in regional development of new transportation modes.

- *Efficiency regulation*. States may choose to establish efficiency standards for vehicles. Because of political sensitivities surrounding this issue, the most successful programs of this type often target distinct sectors, such as establishing fleet fuel efficiency standards for fleets or emission limits for fleets. This may include fleet-specific promotion and use of electric and alternative fuel powered vehicles, although the benefits of these vehicles may vary between regions for a variety of reasons.

- *Support and sponsorship of institutional development*. This may include establishing incentives for shifting between modes of freight transport, supporting regional efforts for rail electrification in areas where electricity is produced with little greenhouse gas emissions, and working with industry and other organizations to promote efficiency and support other innovative measures.

- *Fuel efficiency regulation and enforcement*. This includes establishing and enforcing speed limits, establishing and enforcing state emission and inspection/maintenance standards, and instituting used car efficiency standards.

5.3.3 Use Alternative Fuels

DESCRIPTION

In the long run, alternative transport fuels -- fuels with lower carbon emissions -- offer opportunities to reduce greenhouse gas emissions per unit of travel.[11] The National Academy of Sciences' Mitigation Panel divided alternative fuels into three categories (NAS, 1991):

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[11] Emissions from fuel production, such as the extraction and processing of fossil fuels, mining and processing of uranium for electricity generation (and reactor waste), as well as emissions from the cultivation, harvesting, and processing of energy crops for ethanol fuels are factors to consider while estimating long-term emissions from gasoline and alternative fuels.

1) Those that could (a) result in increased greenhouse emissions relative to gasoline, including: methanol from coal, electricity from coal-fired power plants, and ethanol from biomass but (b) are produced and transported using fossil fuels.

2) Those that will reduce emissions less than 25 percent, relative to gasoline, including: diesel, natural gas in any form, methanol from natural gas, clean/reformulated gasoline with up to 25 percent biomass-derived additives, electricity from gas-fired power plants, and electricity from current power plant fuel mix.

3) Those that eliminate or nearly eliminate greenhouse gas emissions, including: methanol and ethanol from wood biomass using biomass fuel to produce and transport, hydrogen from non-fossil fuel-generated electricity, and electricity from non-fossil fuels.

Conversion to alternative fuels may be controversial because it requires long-term planning, additional capital investment, infrastructure changes, and high levels of political commitment.

CONSIDERATIONS

General consensus indicates that, of the alternative fuels that are under development, those that are most ready for the marketplace will not reduce substantially greenhouse gas emissions from the transportation sector. Those that offer the largest potential reduction in emissions are the furthest from large-scale technical viability, and present the most challenges to wide-scale distribution. Additionally, the successful implementation of any of the available alternative fuels could limit prospects for others in the future, since the delivery systems or required infrastructure may not be compatible. The alternative fuels under consideration also offer shorter operating distances, which may require more extensive supply/filling station networks.

Also, at current oil prices, no single fuel listed above can compete in the marketplace against gasoline. In order for any fuel to displace or even supplement gasoline, investments must be made in the scale of the manufacturing process, in the distribution networks, and in fleet conversions. Environmental or toxicity characteristics may be associated with the new fuel.

Institutional resistance to alternative fuels could be significant: converting to any of the alternative fuels at this point does not offer additional, tangible, and recognized benefits to vehicle operators. Without the certainty of a customer base, few suppliers would venture into the alternative fuels arena. Alternative fuels policies may, therefore, need to address both supplier and customer concerns to ensure program success. An example of a federally-

Exhibit 5-9. Clean Cities

Clean Cities is a voluntary program sponsored by the U.S. Department of Energy. It is designed to accelerate and expand the use of alternative fuel vehicles (AFVs) in urban communities and to provide refueling and maintenance facilities for their operation. Under the Clean Cities program, local governments are encouraged to form a partnership with public and private stakeholders, such as utilities, fuel suppliers, environmental groups, fleet managers, vehicle manufacturers, consumers, and federal, state, and local government agencies. Stakeholders cooperatively draft an implementation plan that quantifies program goals and outlines measures to achieve these goals. DOE provides assistance by operating two national hotlines (Clean Cities Hotline and Alternative Fuels Hotline) and maintaining ten regional support offices throughout the U.S. Additionally, fleet operators interested in acquiring AFVs can coordinate their purchases with the federal acquisition program under the Federal Vehicle Replacement Program. As of September 1997, there were 58 designated Clean Cities. Atlanta was the first of these and has established a goal of having 25,000 AFVs in operation by 1996. Interested parties should contact the Clean Cities Hotline at 1-800-CCITIES for more information.

sponsored program designed to address concerns of all stakeholders is Clean Cities (see box 5-9 for a description).

POLICY OPTIONS

Policy options for promoting use of alternative fuels vary depending on time horizons, government commitment levels, and emission reduction goals. Options include:

- *Target programs to utilize local alternative fuel sources*. The Corn Belt states currently subsidize and publicize fuels made from corn, such as ethanol; other states could similarly promote and develop local resources. These programs may provide experience and knowledge needed for the implementation of larger programs.

- *Convert state or city-owned fleets to alternative fuels*. Governments may directly reduce emissions and demonstrate alternative fuel feasibility by converting their own state vehicles and mass-transit vehicles to use alternative fuels. For example, Burlington, Vermont, and Portland, Oregon, are converting their fleets.

- *Support research and development programs*, including research of non-fossil fuels, research of promising "transition" strategies, and research and incentives for electric/hybrid design and development. Despite the barriers associated with alternative fuels, states could consider sponsoring pilot programs for demonstration and feasibility study purposes.

- *Provide incentives to support institutional development*, including incentives for vehicle conversion, filling station/distributor conversion, alternative fuel vehicle purchase, alternative fuel use in private and government fleet vehicles, and innovative programs to replace gasoline.

5.4 METHANE FROM NATURAL GAS AND OIL SYSTEMS

Methane is the principal component of natural gas. Any leakage during the production, processing, transmission, and distribution of natural gas will therefore contribute to methane emissions. Natural gas is often found in conjunction with oil, and thus gas leakage during oil production and transportation is another source of methane, though minor in the United States. Therefore, options for reducing methane emissions from oil production and transportation are not addressed here.

The U.S. natural gas system is subject to both state and federal regulations controlling leakage, primarily out of public safety concerns. As a result, the U.S. natural gas industry is one of the most efficient systems in the world, in terms of methane emitted per quantity of gas produced. More recently, stringent regional air quality regulations (*e.g.*, controlling VOCs and NOx emissions) impact the operation of natural gas systems, and compliance with these regulations will undoubtedly affect emissions of methane from various stages of the gas system. The rate regulation of the U.S. gas industry by FERC and state PUCs can also help determine the economic feasibility of actions taken by gas companies. State policies designed to reduce emissions from natural gas systems will need to consider the influences of existing economic and safety regulations.

A number of technical approaches exist to reduce methane emissions from natural gas systems. Many of these approaches can be cost-effective for firms in the natural gas industry and ultimately beneficial to natural gas consumers. In fact, many of the approaches discussed here are already in use by companies in the U.S. natural gas industry. State programs addressing informational and institutional barriers to the continued implementation of these technologies could reduce methane emissions in the short term.

DESCRIPTION

The natural gas system includes production sites, processing and storage facilities, and transmission and distribution networks. Methane is emitted from a wide variety of components, processes, and activities in each of these stages. Because the majority of emissions occur in the production, processing, transmission, and distribution stages, options for storage facilities are not considered here. This section focuses on emission reduction options with the highest potential impact, in terms of both the technical and economic feasibility of reducing methane emissions.

The production and processing of natural gas accounts for about 40 percent of methane emissions from U.S. natural gas systems; transmission of gas to distribution facilities accounts for another 35 percent; the distribution of gas to end users through smaller, lower pressure pipes accounts for around 10 percent; and compressor engine exhaust accounts for about 15 percent. The majority of these emissions result from leaks (fugitive emissions), venting from equipment such as pneumatic devices and gas dehydrators, venting during routine maintenance, and compressor engine exhaust (U.S. EPA, 1993a). Options are available for reducing emissions from all of these sources.

- *Pneumatic devices* are gas-powered devices used on heaters, separators, gas dehydrators, and gathering pipelines which control the flow of gas through the facility. Many designs vent (or "bleed") the gas which is used to operate these devices. Options to reduce emissions from these devices include replacing high-bleed pneumatics (devices with high emissions) at the end of their useful life with low- or no-bleed designs where technically appropriate throughout the production stage.

- *Fugitive emissions* are unintentional and usually continuous releases associated with leaks caused by the failure of the integrity of the system, such as a damaged seal, a corrosion pit resulting in a pinhole leak in a pipeline, or inadequately sealed valves, fittings, and assemblies. The primary option for reducing fugitive emissions is the implementation of directed inspection and maintenance programs.

- *Gas dehydrators*, which use a desiccant such as glycol to remove moisture from produced gas, emit methane when the saturated desiccant is regenerated. Options for reducing these emissions include installing flash tank separators before the regenerating unit, and recovering and using the separated methane for boiler fuel (in the regenerating unit).

- *Reciprocating engines* are used throughout the industry to drive compressors that transport gas. These engines emit considerable quantities of methane in their exhaust due to incomplete combustion. The primary option to reduce these emissions is to use turbine engines, which emit significantly less methane, as new transmission lines are constructed and old reciprocators are replaced. This determination needs to be made on a site-specific basis.

- *Venting during routine maintenance* of pipelines occurs when the natural gas must be removed from a section of pipe for safety reasons during repairs. Options for reducing these emissions include using portable evacuation compressors to pump the gas from the section of pipe to be repaired to an adjoining section, rather than venting the gas to the atmosphere. With current gas prices, however, this technology may not be cost-effective in the United States.

In addition to these near-term options for reducing emissions, a variety of technologies and practices that are currently under development may become available commercially over the next decade. These options include: (1) metallic coated seals would be used in place of the rubber seals currently used on moving shafts -- such as shafts in production wells and compressors; (2) "smart regulators" which adjust the pipeline pressure to better accommodate demand at a given time; (3) clock spring composite wraps which can be used to repair leaks on major pipelines without venting the gas; and (4) catalytic converters, which would oxidize the methane released from reciprocating engines. Catalytic converters are increasingly required to comply with air emission regulations for NOx and hydrocarbon emissions.

CONSIDERATIONS

The implementation of options to reduce methane emissions from natural gas systems should focus on high impact applications, such as those discussed above. Because these options can usually be implemented in a short period of time, they will have an immediate impact on reducing emissions. The experience of gas companies in the U.S. shows that many of these options can be cost-effective. Moreover, the economic feasibility of these options will likely improve with the anticipated increases in gas prices over the next decades.

The benefits of the options discussed are not solely related to reduced methane emissions. In addition to being profitable in their own right, these options improve operational efficiency and further reduce safety risks associated with gas leaks. Options to reduce engine exhaust will also reduce the emissions of local air pollutants that form low-level ozone -- NOx and VOCs.

POLICY OPTIONS

- *Provide Information*. A significant barrier to reducing methane emissions from natural gas systems is that information on the economic benefits of emission reduction techniques has not been disseminated widely throughout industry. The other benefits associated with these options have also not been disseminated. States could develop information campaigns to advertise successful programs to industry, regulatory institutions, and other relevant organizations.

- *Address Institutional Barriers*. In many cases, public utility rate structures provide little incentive for reducing methane emissions to the atmosphere. Allowing most of the cost of unaccounted-for-gas to be passed through to consumers, for example, provides little incentive for a company to exceed existing safety standards. State regulatory agencies could develop incentives and remove disincentives to applying technologies and practices that reduce methane emissions. For example, a state public utility commission could adopt regulations that would allow a distribution company that has demonstrated methane emissions reductions to receive a higher rate-of-return on investment so that the value of the gas saved could be allocated to shareholders rather than consumers.

- *Support Research and Development*. States could fund targeted research to reduce costs and to develop improved technologies and practices.

5.5 METHANE FROM COAL MINING

Methane and coal are formed together during coalification, a process in which biomass is converted by biological and geological forces into coal. Methane is stored within coal seams and also within the rock strata surrounding the seams. Deep coal seams have a substantially higher methane content than shallow coal seams, because geological pressure intensifies with depth and prevents increasingly larger amounts of methane from escaping. Methane is released when pressure within a coalbed is reduced, either through natural erosion or faulting or through mining.

State and federal regulations concerning the release of coal mine methane have been developed as a result of safety, rather than environmental, concerns; methane is explosive in low concentrations and hazardous in underground mines. State mine inspectors and the federal Mine Safety and Health Administration (MSHA) share responsibility for monitoring methane levels in underground mines.

Exhibit 5-10. Jim Walter Resources: Methane Recovery Projects

Since the early 1980s, Jim Walter Resources (JWR) has recovered methane from four coal mines in Alabama. Each year, about 13 Bcf of high-quality methane is produced from a variety of mine degasification approaches sold at a nearby pipeline. JWR estimates that this program has reduced mining costs by more than $1/ton and enabled the continued economic operation of these coal mines. In addition, the company is preventing a significant amount of methane from being emitted each year.

For both safety and environmental reasons, other aspects of coal mining are heavily regulated. Federal and state energy, environmental, labor, land management, and other agencies regulate different aspects of the coal mining industry. Significant federal controls include the Coal Mine Health and Safety Act, which regulates virtually all aspects of mining methods and equipment design in order to reduce the dangers of roof falls, explosions, exposure to respirable coal dust, and mechanical accidents. Environmental impacts associated with coal mining -- including geological and hydrological disturbances, blasting, coal preparation, and waste disposal -- are subject to regulation under the Surface Mine Reclamation and Control Act (SMCRA) and state laws and regulations. Additionally, regulations targeting emissions from coal combustion for electricity production significantly impact the coal mining industry. State policies designed to reduce methane emissions from coal mining will need to be coordinated with existing federal and state safety and environmental regulations.

There are two technical approaches for reducing methane emissions from coal mining. The first approach is to recover methane before, during, or after mining and to use it as an energy source. The second approach is to reduce coal-fired energy consumption, which would reduce the amount of coal produced and, accordingly, the amount of methane released from coal mining.

5.5.1 Methane Recovery and Use

DESCRIPTION

Depending on the portion of coal that is produced by large and gassy mines in a state, encouraging utilization of coal mine methane can significantly reduce methane emissions. Methane released from underground mines can be recovered and sold to pipeline companies or used as a feed stock fuel to generate electricity for on-site use or for sale to off-site utilities. For pipeline sales, a coal mine would need to install gathering lines to transport the methane to a commercial pipeline. For power generation, a mine would need to install either an internal combustion engine or gas turbine, both of which can be adapted to generate electricity from coal mine methane. Most methane recovery and utilization technologies can be installed within a year.

Coal mine methane is recovered in a range of purities. Pipeline sales require nearly pure methane, while power generation is a technically viable option for methane concentrations as low as 30 percent (U.S. EPA, 1993b). Techniques for recovery include drilling wells before, during, or after mining. Wells drilled several years in advance of mining will generally be the most expensive, but will recover large amounts of nearly pure methane (up to 70 percent of the methane that would be otherwise emitted). Wells drilled during or after mining can also recover substantial quantities of methane (up to 50 percent of emissions), but the methane may be contaminated with mine ventilation air (U.S. EPA, 1993b). While such a methane/air mixture is normally suitable for power generation, injection into pipelines would require enrichment of the gas, which may not be economically feasible.

Established techniques exist for recovering methane. In fact, over 30 U.S. mines already use recovery wells as a supplement to their ventilation systems to ensure that methane concentrations remain below acceptable levels (U.S. EPA, 1993a). However, this recovered methane is normally released to the atmosphere.

In addition to the highly concentrated methane produced by recovery wells, methane that is emitted in low concentrations in ventilation air also could be utilized. Ventilation air may be used as the combustion air in an on-site turbine or coal fired boiler. However, at the current time, utilization of ventilation air has not been technically demonstrated.

In cases where it is not possible to utilize the recovered methane as an energy source, the gas could potentially be flared, which involves burning the methane so that primarily carbon dioxide, rather than methane, is emitted. However, flaring is not currently considered to be a feasible option for coal mines due to safety considerations, although research is being conducted on this topic. For example, the Energy Policy Act of 1992 includes a provision for further study of this technical approach.

CONSIDERATIONS

Implementation of methane recovery systems should focus on large and gassy mines; in general, recovery and use will be economic only for mines with high coal production and high methane emissions per ton of coal mined. A majority of these mines are located in the Central and Northern Appalachian basins (primarily Pennsylvania, Virginia, West Virginia, and eastern Kentucky), the Warrior basin (Alabama), and a few southwestern states. However, other states may also have mines for which methane recovery and use may be economic.

A few large and gassy mines can account for a very large portion of total state coal mining emissions, and encouraging their use of coal mine methane can significantly reduce emissions. Furthermore, developing methane recovery and utilization projects will have an immediate impact on reducing greenhouse gas emissions. Recovery wells and utilization equipment can usually be installed within a year.

Implementation of programs to encourage recovery and use of methane is facilitated by the fact that such projects can be profitable for coal mines. Currently, ten mines located in Alabama, Virginia, and Utah are making a profit by selling recovered methane to pipelines (See Exhibit 5-10). In 1993, these ten mines recovered for sales to pipelines about 25 bcf of methane that would other wise have been emitted to the atmosphere (U.S. EPA, 1994b). On-site power generation may also be profitable for coal mines.

Given their large electricity requirements, coal mines may realize significant economic savings by generating power from recovered methane. Nearly every piece of equipment in a mine operates on electricity, including mining machines, conveyor belts, ventilation fans, and elevators for workers. Furthermore, the gassiest mines may be able to generate power in excess of their own on-site needs; this excess power could be sold to a utility.

Finally, the benefits of methane recovery and use are not limited to reducing emissions. Recovery and use of methane reduces the risk of explosion in mines, reduces costs for mine ventilation, contributes to energy efficiency by utilizing an otherwise wasted resource, and may create additional financial revenues for coal mines and additional jobs in methane production.

POLICY OPTIONS

Policy options described here focus on programs that could either best be developed at the state level or that could augment federal programs that are planned or already in progress.[12]

- *Provide Information*. The utilization of recovered methane is still a relatively new concept in the coal mining industry. States can disseminate information on methane recovery options and highlight instances of successful methane recovery projects. State agencies may also find a role in identifying and attracting investors in coal mine methane projects and facilitating linkages between local coal companies and potential partners.

- *Support Research and Development*. Several technologies that might help reduce coal mine methane emissions -- such as gas enrichment processes and utilization of mine ventilation air as combustion air -- lack technical demonstration. Additional research is also needed on flaring. States may be able to support research on the potential application of such technologies at coal mines within their jurisdictions.[13]

- *Address Legal Barriers*. Unresolved legal issues concerning the ownership of coal mine methane resources constitute one of the most significant barriers to coal mine methane recovery. For example, ambiguity regarding who may demand compensation for resource development provides a disincentive for investment in coal mine methane projects. Potentially, entitlement could rest with the holder of the coal rights, the owner of the oil and gas rights, the surface owner, or a combination of the three. As part of the Energy Policy Act of 1992, states will be required to develop a mechanism to address ownership issues.[14] One option, enacted by Virginia, is to force pooling of all potential interests in the resource. Under forced pooling, until such time as ownership is decided, payment of costs or proceeds attributable to the conflicting interests are paid into an escrow account. This legislative effort resulted in the rapid development of coal mine methane projects in Virginia (U.S. EPA, 1993b).

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[12] Under the National Energy Policy Act of 1992, the Secretary of Energy, in consultation with the EPA and the Department of Interior, is instructed to study the technical, economic, financial, legal, regulatory, institutional and other barriers to coalbed methane recovery. This study is to be submitted to Congress in October 1994.

[13] States should be aware that the Energy Policy Act of 1992 mandates the establishment of a federal demonstration and commercial application program for advanced coalbed methane utilization technologies.

[14] As part of the Energy Policy Act of 1992, those states determined by the Secretary of Interior as not having statutory or regulatory procedures for addressing ownership concerns will have three years to enact such a program. If the state does not act, the Secretary of Interior will impose a forced pooling mechanism similar to that enacted in Virginia.

- *Address Institutional Barriers*. Pipeline capacity is severely limited in many coal producing regions, which can make it difficult for coal mine methane producers to gain reliable access to pipelines or may necessitate the construction of extensive gathering systems. Accordingly, states with limited pipeline capacity may wish to encourage or expedite new pipeline construction. Similarly, electric utilities in many coal producing regions have excess capacity and low generating costs. Accordingly, utilities may have low "buy-back" rates for power generated from coal mine methane. Furthermore, due to concern over losing a large customer, utilities may discourage coal mines from generating power for their own use. States could consider adopting provisions to encourage power generation from environmentally preferred power producers, such as coal mine methane projects. States may also evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use. Section 5.2 of this document, which addresses "supply-side" measures for reducing greenhouse gas emissions from the electric utility sector, discusses these policy options in greater detail.

- *Provide Financial Incentives*. Though methane recovery and use may be immediately profitable for some mines, others may find these projects economically feasible only if given appropriate financial incentives. For example, low interest loans for investment in recovery and utilization projects could encourage recovery methods that would capture the greatest amount of methane. A state-issued production tax credit could also encourage methane recovery (*e.g.* a $/mcf of gas or cents/kwh of electricity produced credit against state tax liability).[15]

- *Ensure Appropriate Operating Standards*. Coal mine methane wells, although similar to conventional natural gas wells, have important technical differences that may necessitate the development of state regulations specifically addressing this type of production. These regulations may be related to well spacing, coal mine safety, and produced water treatment and disposal. States without an existing coal mine methane industry may need to investigate the adequacy and applicability of existing regulations and modify them as appropriate to ensure the safe, environmentally beneficial, and effective production of coal mine methane. The coalbed methane industry has cooperated with regulators in states like Alabama and New Mexico to facilitate the rapid development of appropriate regulatory frameworks. Such regulations may serve as a model for state initiatives to expedite coal mine methane development.

- *Require Methane Recovery and Use*. States could directly require underground mines to recover and use methane. However, this may not be a viable policy option for several reasons, including: (1) methane recovery and use is most economic for mines with high methane emissions; and (2) recovery and use could not be mandated unless there were guaranteed gas or electricity markets for the recovered methane.

5.5.2 Reduce Coal-Fired Energy Consumption

A second technical approach to controlling coal mine methane emissions is to reduce coal-fired energy consumption. This approach would reduce the demand for coal and thus reduce the level of mining activities and the resulting methane emissions. Importantly, this approach could be adopted by most states,

[15] In 1979, the U.S. Congress enacted the "Section 29" tax credit in order to encourage the development of unconventional gas resources. The eligibility of coalbed methane production under the Section 29 tax credit has expired as of the end of 1992 and gas produced from coalbed methane wells will only be eligible for the credit if they are drilled prior to the expiration date.

regardless of the amount of coal they produce because nearly all states consume electricity from coal-fired power plants. Reducing coal-fired energy consumption could be achieved by encouraging energy efficiency and/or by encouraging fuel switching from coal-fired electricity production to less polluting energy sources. Programs designed to reduce coal-fired energy consumption would likely be implemented in conjunction with general policies targeted to encourage energy efficiency and fuel-switching. See Sections 5.1 and 5.2 for more information on energy consumption and production.

5.6 METHANE FROM LANDFILLS

Landfills are the largest single anthropogenic source of methane emissions in the United States. Municipal solid waste (MSW) landfills account for over 95 percent of landfill methane emissions, with industrial landfills accounting for the remainder (U.S. EPA, 1993a). Methane is produced during the bacterial decomposition of organic material in an anaerobic (*i.e.*, oxygen deprived) environment. The rate of landfill methane production depends on the moisture content of the landfill, the concentration of nutrients and bacteria, temperature, pH, the age and volume of degrading material, and the presence or absence of sewage sludge. Once produced, methane migrates through the landfill until a vertical opening is reached and the gas escapes into the atmosphere.

There are two basic approaches for reducing methane emissions from landfills. The first approach is to recover the methane and to either flare the gas or use it as an energy source. The second approach involves reducing the quantity of degradable organic waste produced and deposited in landfills. In addition, these approaches support other state environmental and public health priorities, such as protecting air, surface water and ground water resources.

5.6.1 Methane Gas Recovery

DESCRIPTION

Landfill gas produced in a sealed landfill can easily be captured by installing a gas recovery system. Landfill gas is typically 50 percent methane (along with 45 percent carbon dioxide and 5 percent other gases including hydrogen sulfides and volatile organic compounds (VOCs)), and is therefore a medium quality gas that can be: (1) recovered, purified, and used to generate electricity; (2) used as a source of natural gas for residential, commercial, or industrial heating needs; or (3) combusted in a flare. In addition, there are several emerging utilization technologies that may be commercially available in the near term, including using landfill gas as a vehicle fuel and/or in fuel cell applications. Gas recovery essentially involves "mining" the trapped methane. This process consists of drilling wells into the landfill, withdrawing the gas under negative pressure, and gathering the recovered gas at a central processing center. Unlike strategies concentrated on reducing the amount of degradable waste landfilled (which curb future methane emissions), methane gas recovery reduces current methane emissions. Recovering methane has other environmental and safety benefits as well, such as reducing the risk of explosions, reducing odor, and reducing emissions of air toxics and non-methane volatile organic compounds.

Methane gas recovery and utilization technologies are widely available, and projects have costs similar to other relatively small renewable energy technologies.[16] The profitability of landfill gas energy recovery projects depends on a range of factors, including the volume of recovered methane, the price

[16] Costs for methane recovery range from $5,000 to $10,000 per acre for installation. Combustors for flaring range from $15,000 to $90,000. To purify the gas for use in internal combustion engines costs from $50,000 to $300,000 for purification (IPCC, 1992b).

obtained for electricity (or gas) sales, and the availability of tax incentives. Currently, there are more than 150 fully operational landfill gas recovery and utilization projects in the United States, recovering about 1.3 teragrams, or 66 billion cubic feet, of methane gas per year. Nearly 100 additional gas recovery projects are underway around the country. EPA estimates that there may be an additional 500 profitable landfill gas energy recovery projects that could be developed in the U.S., but are constrained by informational, regulatory, and other barriers. Methane can also be flared, which almost completely eliminates the methane contained in the gas, but wastes the energy value of the gas.

Before recovered landfill gas can be used as a fuel source, it must be processed to remove water, particulates, and corrosive compounds. Processed landfill gas can be used to power an electric generator, such as a gas turbine or an internal combustion engine. Thermal energy from combustion can also be used to drive a steam turbine to increase electricity production. Alternatively, landfill gas can either be used directly for industrial, commercial or domestic energy purposes, or upgraded to a high-Btu fuel suitable for supplying a natural gas pipeline.

CONSIDERATIONS

Implementation of landfill gas recovery and utilization projects should focus on large landfills (over 1 million tons of waste-in-place), which will most likely have a high enough gas flow to support a profitable project. While landfill gas recovery will be particularly relevant for states with large urban centers, and their associated large municipal solid waste landfills, all states will have several landfills at which landfill gas recovery may be a viable option.

Landfill gas projects can provide many important environmental and economic benefits. They improve the global environment by reducing methane emissions, and the local environment by reducing emissions of volatile organic compounds (VOC), while simultaneously displacing emissions associated with fossil fuel use. They also provide a secure, low-cost energy supply that can reduce dependence on non-local energy. They also reduce the waste of valuable natural gas by preventing it from being emitted to the atmosphere. In addition, these projects can provide economic benefits, such as creating jobs and generating revenues.

Traditionally, landfill methane has been viewed as a safety hazard and a general nuisance. However, there is an increasing awareness on the part of state and local governments, landfill owners and operators, utilities, and industry, of the environmental, energy, and economic benefits that can result from recovering, rather then emitting or flaring, this gas. For example, utilities, which are a major market for electricity generated at landfills, can play an important role in encouraging economically attractive projects. The benefits of these projects to utilities include: promoting a diversified fuel mix; obtaining additional Acid Rain Credits; and fulfilling Climate Challenge commitments.[17] Utilities can also market power generated from landfill gas as “green power,” thereby appealing to consumers’ increasing interest in environmentally benign products. Landfill owners and operators can benefit by reducing regulatory costs and improving landfill safety. EPA's *New Source Performance Standards and Emission Guidelines,* promulgated on March 12, 1996, require many landfill owners and operators to collect and, at the very least, flare their landfill gas. Utilizing the collected gas for an energy recovery project may offer owners

[17] Climate Challenge, sponsored by DOE, is a CCAP initiative targeted at electric utilities. This action encourages electric utilities and other eligible firms to submit voluntary greenhouse gas reduction portfolios to DOE for inclusion in the Energy Information Administration's database. Through Climate Challenge, DOE is also attempting to stimulate the development and application of clean, sustainable energy technologies, strengthen the U.S. position in the global environmental technology marketplace, and contribute to overall environmental quality.

and operators an opportunity to offset regulatory costs or even generate a profit. Local industries can also benefit from encouraging or participating in landfill gas energy recovery projects by obtaining an inexpensive source of medium quality fuel (or steam, if the project is generating electricity).

POLICY OPTIONS

- *Provide Information.* States can provide landfill owners, project developers, and other interested parties with information on landfills that are candidates for methane recovery projects, on potential electricity purchasers (*i.e.*, utilities and industrial end-users), and on relevant regulatory policy and permitting issues within their state. EPA's Landfill Methane Outreach Program (LMOP) works cooperatively with states to encourage landfill gas energy recovery projects by developing and disseminating these types of information. For this purpose, the LMOP has developed many publications and tools,[18] including:

  * *E-PLUS decision support software*: assists landfill owners and operators in evaluating the costs of landfill gas collection and use.

  * *End-user locator software* (currently under development): helps landfill owners and operators and project developers find buyers for the energy they produce by identifying potential end-users, including schools, prisons, industries, and others.

  * *State Primers:* developed for every state that becomes an ally to the program. Primers facilitate communication and cooperation between states and project developers by identifying project opportunities, detailing pertinent regulations, and providing contact information for individuals at relevant state agencies.

  * *Landfill Profiles database:* lists all landfills that are candidates for gas utilization projects in selected states. The database includes many factors relevant to the development of projects, including landfill name, location, size, gas generation capacity, regional electricity prices, and whether or not the landfill has a gas collection system in place.

  * *Guidance Documents and periodic reports:* can be provided by states to project developers and interested landfill owners. These documents include a guide to understanding the Landfill Rule, the Ally Report and the Ally Update (periodic reports providing information on issues affecting development of landfill gas energy recovery projects), project financing guidance documents and brochures, and "Turning a Liability into an Asset: a Project Development Handbook".

  LMOP representatives also meet with state agencies throughout the country to discuss ways that states can support and encourage development of landfill gas-to-energy projects.

- *Address Institutional Barriers.* Electricity pricing and transmission line access and capacity may confound the development of landfill gas recovery projects. States with limited pipeline capacity may wish to encourage or expedite new pipeline construction or grant environmentally beneficial producers preferential access to existing electric power lines. States could consider adopting

[18] LMOP products, including E-PLUS, state primers, and other guidance documents, can be ordered by calling the LMOP Hotline at 1-888-STAR-YES (782-7937).

provisions to encourage power production from landfills and evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use or for sale to the utilities (see also Sections 5.1 and 5.2).

State regulatory policy and permitting procedures can also present barriers to landfill gas projects. For example, the siting of the electricity generation equipment associated with a project can be extremely difficult in some regions, even though these projects have positive impacts on local air quality. In general, the permitting process for small unconventional power projects can hinder the implementation of these projects. In some cases, regulations concerning the placement and operation of collection wells, developed for gas migration control, can interfere with optimal well placement for gas recovery and utilization. States can review their policies and procedures in order to reduce unnecessary barriers to these types of projects. EPA's Landfill Methane Outreach Program is working cooperatively with state allies to conduct interagency reviews of state regulations and permitting procedures.

- *Provide Financial Incentives*. Methane recovery projects can be encouraged through tax credits, loans or grants for capital investment in methane collection equipment, and state and private investment in research and development of landfill gas recovery technology. States can provide production tax credits to landfill operators that initiate methane recovery for power production or offer consumption tax credits to utilities that purchase methane from landfill projects. States may also subsidize electric transmission line upgrades, pipeline upgrades, and offer other incentives to extend gathering lines to allow for transport of additional capacity. Additionally, states could impose an emissions tax on methane released to the atmosphere or diversion credits for emissions avoided through methane recovery.

5.6.2 Keeping the Organic Fraction of Municipal Solid Waste Out of Landfills

DESCRIPTION

When organic materials are landfilled, some of the carbon is converted by methanogenic bacteria to methane, carbon dioxide, and other gases, and some of the carbon is sequestered. Organic materials that produce significant amounts of methane include paper, yard trimmings, and food scraps. Preliminary research by EPA indicates that when office paper, corrugated cardboard, food scraps, or grass clippings are landfilled, the GHG emissions from methane generation outweigh the GHG sink due to carbon sequestration (EPA, 1997). By keeping these materials out of landfills (through recycling or composting), states can reduce net GHG emissions from the waste management sector.

There are several approaches to reduce the amount of these organic materials landfilled. These include source reduction, recycling, composting, and combustion. Source reduction and recycling also generally reduce the use of fossil fuels in manufacturing, further reducing GHG emissions. This section focuses on keeping the organic fraction of municipal waste out of landfills. Further information on methods to reduce GHGs from municipal waste management (including a more comprehensive discussion of the opportunities for source reduction and recycling) may be found in Section 6.2.

CONSIDERATIONS

The simplest method of managing yard trimmings is "grasscycling," or leaving grass clippings in place on the lawn to decompose. Some homeowners prefer to use a "mulching mower" for this purpose. In a state with a population of 5 million, and the national average rate of generation of grass clippings, grasscycling will reduce GHG emissions by 10,000 metric tons of carbon equivalent (MTCE) per year, compared to landfilling the grass clippings.

Yard trimmings may also be composted, either in a backyard compost pile or bin, or in a centralized composting operation. Backyard composting eliminates GHG emissions from waste transportation. Centralized composting by a municipality requires land, labor, and a distribution system for the finished compost. Much of the compost may be used for municipal landscaping or highway projects. Alternatively, centralized composting may be done by farmers. In such cases, the municipality typically transports yard trimmings to a farm, where the farmer accepts them at no cost to the municipality. The farmer then makes compost from the yard trimmings, and uses the compost on the farm.

Food scraps may, similarly, be composted either in backyards or in a centralized operation. Commercial composting of food scraps is becoming more common.

Paper may be kept out of landfills through recycling. Prices for recovered office paper and corrugated boxes, in particular, have been consistently good, suggesting that it is particularly cost-effective to recycle these types of paper. An added advantage for recycling office paper and corrugated boxes is that they are generated by commercial sources, so that collection efforts yield high quantities.

Alternatively, paper, food scraps, and yard trimmings may be combusted. Particularly when the combustor incorporates energy recovery, this waste management method generally results in lower GHG emissions than landfilling.

POLICY OPTIONS

States have a number of policy options for keeping organic materials out of landfills. The most popular policy among states to date is a ban on landfilling of yard trimmings; by early 1997 23 states had instituted such bans. Yard trimmings in these states are either composted, combusted, or left on the ground to decay naturally.

States may also promote or require recycling of paper and other materials. To promote recycling, Oregon requires haulers to collect recyclable materials from businesses, and requires that collection service be provided at a cost that does not exceed refuse collection costs.

Composting of food scraps is a significant area of opportunity for further reducing the amount of organic waste going to landfills. Some communities offer households free recycling bins for this purpose.

An educational campaign can be instituted to promote any of the options discussed above. A relatively low-cost policy option would be an educational campaign to promote grasscycling, as well as backyard composting of yard trimmings and food scraps. Minnesota and Pennsylvania are two states that have extensive educational campaigns to promote recycling and composting.

5.7 METHANE EMISSIONS FROM DOMESTICATED LIVESTOCK

Methane is produced as part of the normal digestive processes of animals; this process is referred to as "enteric fermentation." Of domesticated animals, ruminant animals -- including cattle, buffalo, sheep, goats, and camels -- are the major source of methane emissions. Ruminant animals are characterized by a large "fore-stomach" or rumen. Microbial fermentation in the rumen enables these animals to digest coarse plant material that monogastric animals, including humans, cannot digest. Methane is a byproduct of this microbial fermentation.

In the U.S., cattle account for nearly all methane emissions from enteric fermentation. Factors affecting methane production from individual animals include: the physical and chemical characteristics of the feed, the feeding level and schedule, the activity and health of the animal, and possibly genetic traits (U.S. EPA, 1993a). Of these factors, the feed characteristics and feed level most influence the amount of methane produced.

In general, methane production by livestock represents an inefficiency because the feed energy converted to methane is not used by the animal for maintenance, growth, production, or reproduction. While efforts to improve efficiency by reducing methane formation in the rumen directly have been of limited success, it is recognized that improvements in overall production efficiency will reduce methane emissions per unit of product produced. A wide variety of techniques and management practices are currently implemented to various degrees among the U.S. livestock producers which improve production efficiency and reduce methane emissions per unit of product produced. More widespread use of these techniques, as well as the implementation of new techniques, will enable methane emissions from livestock to be reduced.

No existing federal or state regulations specifically focus on reducing methane emissions from domesticated livestock. However, government and industry efforts designed to promote animal production efficiency will also indirectly reduce methane emissions. Several techniques including genetic improvements and the use of productivity-enhancing agents as well as changes to the marketing system for milk and meat products, including the milk pricing system and the beef grading system could potentially reduce methane emissions from livestock (EPA, 1993b).

5.7.1 Improve Production Efficiency Per Animal

DESCRIPTION AND CONSIDERATIONS

Improving livestock production efficiency so that less methane is emitted per unit of product is the most promising and cost effective technique for reducing emissions in the U.S. While U.S. livestock production is among the most productive in the world, opportunities for improvement exist for all sectors of the cattle industry that can reduce methane emissions substantially. In many cases these options can be profitable because they reduce costs per unit of product produced.

Specific strategies for reducing methane emissions per unit product have been identified and evaluated for each sector of the beef and dairy cattle industry. Throughout the industry, proper veterinary care, sanitation, ventilation (for enclosed animals), nutrition, and animal comfort provide the foundation for improving livestock production efficiency. For many producers, focusing on these basics provides the best opportunity for improving production efficiency. Within this context, a variety of techniques can help improve animal productivity and reduce methane emissions per unit of product.

- *Dairy Industry*. Significant improvements in milk production per cow are anticipated in the dairy industry as the result of continued improvements in management and genetics. Additionally, production-enhancing technologies, such as bST, are being deployed that accelerate the rate of productivity improvement. By increasing milk production per cow, methane emissions per unit of milk produced declines (EPA, 1993b).

- *Beef Industry*. Improving productivity within the cow-calf sector of the beef industry requires additional education and training. The importance and value of better nutritional management and supplementation must be communicated. Energy, protein, and mineral supplementation programs tailored for specific regions and conditions need to be developed to improve the implementation of these techniques. The special needs of small producers must also be identified and addressed (EPA, 1993b).

In addition to these near term reduction strategies, several very long term options may become available as the result of ongoing research, including: the transfer of desirable genetic traits among species (transgenic manipulation), the production of healthy twins from cattle (twinning); and the bioengineering of rumen microbes that can utilize feed more efficiently.

POLICY OPTIONS

Though significant efforts by the dairy and beef industries and the U.S. Department of Agriculture are already underway to research and/or promote adoption of practices that will improve animal efficiency and reduce methane emissions per unit product, states can also implement policies designed to reduce methane emissions from ruminant livestock.

- *Provide Information*. Through the USDA Cooperative Extension Service, states may be able to develop information campaigns to encourage the use of techniques that improve production efficiency and reduce methane emissions per unit product. States could develop and make information available on the best management practices for different regions of the state, provide feed analysis services to determine actual protein and dry matter content of feeds, and provide information about and access to feed balancing computer programs.

- *Support Research and Development*. States could promote further research on genetic improvement in beef cattle, on identifying critical nutritional deficiencies that could be corrected through mineral or protein supplementation, and on determining the nutrient content of feeds. States may be able to work with industry on these efforts.

- *Provide Incentives*. Generally, the most profitable livestock management practices do not yield maximum biological productivity from the animals (*e.g.,* maximum milk per cow or maximum weaned calf weight per cow). Targeted financial incentives (fees and rebates) tied to verifiable <u>productivity</u> measures could be used to encourage producers to improve productivity, which would then reduce emissions per unit product produced. Significant research remains to design such an incentive system, including: choosing appropriate and verifiable measures of productivity; developing funding and fee collection mechanisms; and selecting appropriate levels for the incentives.

5.7.2 Improve Overall Production Efficiency of Animal Products by Matching Animal Products to Customer Preferences

DESCRIPTION AND CONSIDERATIONS

The existing systems for marketing milk and meat products in the U.S. have important influences on production efficiency, and hence methane emissions. Refinements to the existing marketing systems hold the promise of improving the link between consumer preferences and production decisions, thereby reducing waste and improving efficiency. Proposed approaches include the following:

- *Dairy Industry*. Dairy industry emissions can also be reduced by refinements in the milk pricing system. By eliminating reliance on fat as the method of pricing milk, and moving toward a more balanced pricing system that includes the protein or other non-fat solids components of milk, methane emissions can be reduced as the result of changes in dairy cow rations and genetics. There is already a trend to reduce reliance on fat in the pricing of milk (EPA, 1993b). To realize methane emissions reductions from this trend, the effectiveness of alternative ration formulations on protein synthesis must be better characterized.

- *Beef Industry*. Refinements to the beef marketing system are needed to promote efficiency and shift production toward less methane emissions intensive methods. To be successful, the refinements to the marketing system require that the information flow within the beef industry be improved substantially. Techniques are required to relate beef quality to objective carcass characteristics. Additionally, the carcass data must be collected and used as a basis for purchasing cattle so that proper price incentives are given to improve cattle quality and reduce unnecessary fat accretion.

  The beef industry has several programs under way to achieve these objectives. Carcass data collection programs have been initiated that provide detailed data on carcass quality to participating producers. Also, a major initiative is ongoing to educate retailers regarding the cost-effectiveness of purchasing more closely trimmed beef (less trimmable fat). As these programs become more widely adopted, the information needed to provide the necessary price incentives to producers will become available.

POLICY OPTIONS

The beef and milk marketing systems are principally regulated through existing federal programs. States have few opportunities to influence these systems through regulatory mechanisms. However, as significant purchasers of milk and meat products, States and related State-influenced institutions (such as schools and hospitals) have an opportunity to purchase milk and meat products in a manner that provides the price signals that lead to improved production efficiency. Significant research remains to be done to fashion an appropriate State-level policy in this regard, but there is substantial potential to influence production practices through the use of specifications in purchase contracts. Alternatives for specifying product characteristics should be explored and opportunities for leveraging purchasing decisions need to be identified.

5.8 METHANE FROM MANURE MANAGEMENT

When livestock manure is handled under anaerobic conditions (in an oxygen free environment), microbial fermentation of the waste produces methane. Liquid and slurry waste management systems are especially conducive to anaerobic fermentation and to methane production. Because confined livestock operations such as dairy and hog farms rely on liquid and/or slurry systems to manage a large portion of their manure, they account for a majority of all animal manure methane emissions in the U.S. Emissions depend on farm characteristics (including number and type of animals, manure management practices, and animal diet) and climatic conditions (including temperature and relative humidity).

In addition to methane emissions, livestock manure can cause surface and ground water pollution, air pollution (*e.g.*, ammonia and strong odors), and human health risks. State and federal regulations require proper manure management practices to avoid these potentially adverse environmental problems. In particular, under Section 319 of the Federal Clean Water Act (CWA), confined livestock operations are regulated as potential point sources of water pollution and are required to control rainfall run-off and to apply manure prudently. This section of the CWA is enforced by individual states through a permit process designed under the National Pollution Discharge Elimination System (NPDES) program.

In order to comply with these federal and state regulations, many confined livestock operations (*i.e.*, non-grazing operations) are utilizing anaerobic lagoons or pits to contain runoff and to manage their manure. These systems are simple, cost-effective, and relatively safe. However, because anaerobic systems produce more methane than aerobic systems, their increased use could significantly increase methane emissions from livestock manure.

5.8.1 Methane Recovery and Use

DESCRIPTION

Feasible and cost-effective technologies exist to recover methane produced from the liquid manure management systems used at dairy and swine operations. Methane can be captured, for example, by placing a cover over an anaerobic lagoon. A collection device is placed under the cover and methane is removed by a vacuum. Alternatively, methane can be recovered from mixed tank or plug flow digesters that produce methane. These and other technologies can be used on individual farms or at centrally located facilities.

Because methane is a fuel, methane gas recovered by any of the available methods provides a renewable energy source. The methane can be used in a variety of equipment:

- *Internal Combustion (IC) Engines*. IC engines are reliable, available in a variety of sizes, and can be operated easily. Electricity generated can be used to replace energy purchased from a local utility or can be sold to the local electricity supply system. Additionally, waste heat from these engines can provide heating or warm water for farm use or for recycling into the recovery system.

- *Boilers and Space Heaters*. Boilers and space heaters fired with methane can produce heat for use in livestock operations. Although this is an efficient use of the gas, it is generally not as versatile as electricity generation and most farms do not require the amount of heating that can be generated.

- *Chillers*. Gas-fired chillers are commercially available and can be used for milk refrigeration on dairy operations. Because dairy farms use considerable amounts of energy for refrigerating milk, chillers may provide a profitable opportunity for on-farm methane utilization.

- *Pipeline Sales*. Available methane can be sold to pipelines for distribution through the existing natural gas pipeline network. However, gas produced from livestock manure is typically composed of about 40 to 50 percent carbon dioxide (CO_2) and trace quantities of other gases such as hydrogen sulfide (H_2S), which need to be removed before the gas can be injected into a pipeline. The cost of upgrading the gas to pipeline quality makes this option uneconomical at the current time.

Exhibit 5-11: Methane Recovery in North Carolina

The Southeast Regional Biomass Energy Program (SERBEP) recently supported a successful demonstration project on methane recovery at a dairy farm near Raleigh, North Carolina. Methane captured from animal waste is a biomass fuel that can be used as a substitute for natural gas or propane. The demonstration project used a methane recovery technique called lagoon digestion, which involves the construction of a deep earthen lagoon in which animal waste is collected. A sealed cover is placed over the lagoon to allow for the collection of methane from the normal digestion of the waste by bacteria. The benefit of the digestion approach is that it does not require elevated temperatures. Furthermore, this technology displayed low operating costs. On average, the project produced 5000 cubic feet of gas per day, with a methane content of 69 percent, which was used to fuel a boiler that provides hot water for the farm's milking parlor.

Methane must be processed before it can be used in most equipment. The amount of processing necessary depends on the specifications of the equipment and the characteristics of the gas.

Depending on the number of large dairy and swine operations in a state, utilization of livestock methane can significantly reduce methane emissions. These systems can reduce emissions at individual farms by up to 80 percent (U.S. EPA, 1993b). Furthermore, developing methane recovery and utilization projects will have an immediate impact on reducing emissions since these systems can be installed within one year.

It should be noted that policies regarding methane recovery systems may be compatible with policies encouraging the use of manure instead of commercial fertilizer. Methane recovery systems could be employed during the storage period before application to fields.

CONSIDERATIONS

Recent trends in manure management, such as using anaerobic lagoons to meet requirements of the Clean Water Act, have prompted interest in developing and installing on-farm methane recovery systems. Many of the operational problems initially experienced with methane recovery systems in the early 1970s have been overcome during the past two decades through advances in the methane recovery industry. EPA's AgStar program focuses on providing support to farms considering implementing methane recovery systems. As of late 1997 there were 40 farm operations participating as AgStar partners.

Implementation of recovery systems usually focuses on large dairy or hog farms (for example, farms with over 500 milking cows or over 1,500 hogs) that use liquid or slurry manure management systems which are especially conducive to methane production. The current trend in livestock production is away from the small family farm (less than 200 cows) with limited manure storage capabilities toward large production farms (over 500 cows) that use manure storage systems as a matter of routine. This trend may mean that an increasing number of farms will find it economic to capture methane. Additionally, methane recovery and use may be more economical for farms located in a relatively warm climate.

POLICY OPTIONS

Policy options described here focus on programs that could either best be developed at the state level or that could augment federal programs planned or already in progress.

- *Provide Information*. One of the most significant barriers to the development of methane recovery projects is lack of information. Current recovery systems must be demonstrated to show that the problems that plagued the earlier systems have been resolved. States can potentially disseminate information on successful methane recovery projects and provide training in the design, construction, and operation of methane recovery systems. For example, states could distribute the AgStar FarmWare software to farmers; this software estimates the net present value of a farmer's investment in a project to capture methane from manure, and use the methane to produce electricity.

- *Support Research and Development*. As recovery technology improves, more farms may find it cost-effective to recover and utilize methane produced from livestock manure. States may further the advancement of these technologies by supporting research and development projects.

- *Address Institutional Barriers*. Several economic barriers that limit the adoption of methane recovery systems are common to other small power producers, cogenerators, or other independent power producers. One problem is low utility "buy back" rates, which limit the value of the energy produced. In the case of methane recovery from livestock manure, low buy back rates may be less significant because usually the energy produced can be used to displace the energy purchased by the farmer from the utility. However, if utilities were to lower their electricity rates in order to compete with these recovery projects, the profitability of these projects would be reduced; profitability is extremely sensitive to electricity rates. States could evaluate the need for actions to ensure that utilities do not inappropriately discourage power generation for on-site use.

- *Evaluate Existing Regulations*. Some existing regulations may hinder the development of recovery systems. In some states, equipment used at livestock operations located near large metropolitan areas must meet air emissions standards that reduce the profitability of the projects. These air emission standards may not consider that these systems are being used to mitigate other harmful emissions. Further, adding a methane recovery system to an existing manure management system may require permit modifications. The cost of applying for and obtaining changes in operating permits reduces the profitability of developing a recovery system. States could evaluate the need for modifying existing regulations that may constrain the wider development of recovery projects.

- *Provide Financial Incentives*. Though methane recovery and use may be immediately profitable for some farms, other farms could find projects to be economically feasible if given appropriate financial incentives. For example, inadequate capital financing may limit the ability of farmers to purchase a recovery and utilization system; this barrier could be addressed through the provision of low interest loans. A state-issued production tax credit would improve the economics of recovery projects and could encourage more farmers to develop projects.[19]

- *Require Methane Recovery and Use*. States could require confined livestock operations to recover and use methane. However, numerous factors -- such as climate, farm layout, current electricity rates -- may impact whether projects will be economical. When conditions are not conducive to the profitable recovery and use of methane, a recovery requirement could impose a substantial economic burden on some farms, particularly those with the lowest emissions.

5.8.2 Increase Aerobic Treatment of Livestock Manure

DESCRIPTION AND CONSIDERATIONS

A second technical approach for reducing methane emissions from livestock manure is to encourage aerobic treatment of livestock manure at confined livestock operations. Normally, the manure produced from these operations is eventually spread on land which is part of the livestock operation. Land application rates must be matched to the carrying capacity of the soil, which is influenced, for example, by crop needs and the seasonal schedule of the producer. Although manure is produced throughout the year, in most cases it cannot be applied to land at all times of the year, such as when the land is wet or frozen or during the crop growing season. During these times, the manure must be stored until it can be applied to land, which results in anaerobic conditions and methane formation. Alternatively, livestock manure can be composted before it is applied or sold as an organic fertilizer. In most cases, however, the amount of compost that can be produced greatly exceeds the current demand.

Increasing aerobic treatment (*e.g.*, composting) of livestock manure, therefore, could be achieved either by: 1) encouraging aerobic treatment of manure while it is being stored; 2) finding alternative uses for the manure when local application is not possible; or 3) expanding the market for composted manure as a fertilizer. The first option -- encouraging aerobic treatment of the waste -- may not be viable in many areas because it would be in conflict with regulations that encourage confined livestock operations to treat manure anaerobically in order to prevent both air pollution and surface and ground water pollution. For some states, the second and third options may be worth consideration if a sufficiently large market for the manure can be identified.

POLICY OPTIONS

- *Provide Information*. Through the Cooperative Extension Service, states may be able to develop information campaigns to encourage the use of aerobic manure treatment. In addition, states could provide manure nutrient analysis services to farmers to determine the nitrogen, phosphorous, and potassium content of the manure produced on an individual farm and, therefore, maximize manure fertilizer use.

- *Support Research and Development*. States could investigate the potential for alternatives to livestock manure storage and the most efficient methods of composting manure. Further information on the nutrient content of composted manure could assist in evaluating its potential as a complete replacement to inorganic nitrogen fertilizers and encourage its use by non-livestock

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[19] The Energy Policy Act of 1992 includes a renewable energy production incentive. Qualified renewable energy facilities, which would include facilities producing electricity from livestock manure, will be eligible to receive a subsidy of 1.5 cents per Kwh of electricity produced.

producers. This could expand the market for composted manure and decrease the amount stored anaerobically.

- *Provide Financial Incentives*. Aerobic treatment of manure and the transport of manure to other areas may not be economical for small farms that currently spread manure on a daily basis. Financial incentives may be necessary to encourage the use of aerobic treatment and to assist in expanding the market for composted manure fertilizer.

5.9 METHANE FROM RICE CULTIVATION

DESCRIPTION

Methane is produced in flooded rice fields during the bacterial decomposition of organic material. Non-flooded rice fields and deepwater floating rice fields (*i.e.*, greater than 1 meter floodwater depth) are not believed to produce significant quantities of methane. Rice paddy methane production depends on several factors in addition to water depth, including the concentration of nutrients and bacteria, soil temperature and pH, and the oxidation reduction potential.[20] These factors are strongly influenced by agricultural management practices, such as the application of organic matter which can alter the nutrient content of the soil and increase the soil temperature during its decomposition. Once produced, methane can escape by plant-mediated transport or diffusion or bubbling through the water column. In general, rice cultivation is not as large a contributor to methane emissions in the United States as in other parts of the world, due to differences in climate and farming practices.

CONSIDERATIONS

No federal standards exist to limit emissions of methane from rice cultivation. The Department of Agriculture, however, recommends certain agricultural management strategies that affect rice cultivation practices, including (under certain circumstances and particular production areas), shortened rice field flooding periods, which can reduce methane production. Of the six U.S. states that produce significant quantities of rice, including Arkansas, California, Louisiana, Mississippi, Missouri, and Texas, none have implemented direct regulations to reduce methane emissions from rice fields. However, some state regulations restrict water use in agriculture, which may in turn reduce methane production and emissions. These regulations also serve to protect surface water and ground water from pollution.

Scientific uncertainty surrounds the potential to reduce methane emissions from rice production. Several technical approaches including the selection of cultivars (*i.e.*, plant variety or strain), nutrient management, and water regime management have been identified as potential methods to decrease methane emissions from rice cultivation. However, the ability of these methods to decrease emissions is based mainly on experimental data, which often conflict.

Cultivar Selection

The development of rice strains that produce fewer root exudates may help to limit methane production, although researchers are uncertain about the magnitude of this effect. In addition, modern short-stemmed rice varieties have a grain-to-straw ratio that is about 50 percent higher than traditional

[20] Oxidation reduction potential in this instance refers to the electrical potential of the water-sediment environment. In reducing conditions, not enough oxygen is available to sustain aerobic bacteria, and anaerobic bacteria populations prevail.

varieties, and therefore, produce less "wasted" organic material (*i.e.*, rice straw that cannot be harvested). These varieties may potentially reduce greenhouse gas emissions, because they decrease the amount of organic material available to decompose in the soil. Different cultivars, however, may adversely affect the ecology of rice fields and may be more costly than existing strains. Even if the cost of methane-reducing cultivars does not significantly differ from existing strains, rice farmers may be unwilling to accept the costs of conversion or the risks associated with cultivating a different strain, such as potentially reduced yields or poorer quality or taste.

<u>Nutrient Management</u>

Nutrient inputs to rice fields affect methane emissions by altering the methane production rate. Application of nitrogen-based fertilizers, ammonium sulfate, and urea generally reduce methane emissions compared to application of non-commercial fertilizers. Conversely, application of organic fertilizers, such as rice straw and animal wastes, has been found to increase methane emissions.

Many rice growers in the U.S. practice multi-year cropping that involves plowing the crop residue (*i.e.*, rice straw) into the soil before planting a different crop. This management practice, which increases methane emissions, is fairly typical in Texas. The alternative -- reducing organic nutrient input to rice fields -- may reduce methane emissions, but may also decrease rice yields. In addition, rice straw or other organic matter that is not used to fertilize the rice field may either be combusted, composted, or landfilled, all of which produce greenhouse gas emissions. Unlike organic fertilizers, mineral fertilizers (such as nitrogen fertilizers) reduce methane emissions to the atmosphere. However, they contribute nitrous oxide, a greenhouse gas, to the atmosphere and cost considerably more than composted rice straw and other readily available organic waste. Section 5.10 specifically addresses nitrous oxide emissions from fertilizer application.

<u>Water Management</u>

Only through continuous flooding do rice paddies remain sufficiently reduced (lacking in oxygen) for methane production to occur. As water is drained from rice fields, the oxidation reduction potential increases and methane emissions decrease. For example, rice cultivated under dry upland conditions does not produce methane emissions; however, production levels may decrease using this production method. Thus, floodwater depth and the length of the flooding period are factors that affect methane production.

The typical practice in the U.S. is to cultivate rice on flooded fields. These fields are flooded at depths of approximately 5 to 10 cm. However, these fields are not flooded for the entire growing season. Usually, seeds are placed into dry land with limited irrigation for approximately 30 days. The land is then flooded for the remaining growing period. This helps to reduce total seasonal methane emissions.[21] Federal and state water management regulations may limit the amount of water that can be used for agriculture, indirectly limiting methane emissions.

POLICY OPTIONS

Because the potential to reduce methane emissions in rice production is limited and scientific uncertainty surrounds the data on the effectiveness of different methods in reducing methane emissions, more research may be needed before policy changes are implemented.

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[21] Methane emissions increase with increased water levels over the range of flooding levels typically used in rice cultivation in the U.S.

- *Provide Information and Technical Assistance.* State agricultural agencies and the Cooperative Extension Service may be able to provide information to rice growers on the benefits of different cultivars, provide on-site technical assistance, develop demonstration programs on cultivar use and optimal nutrient applications, and on water management regimes.

- *Support Research and Development*. States can support research at universities, non-profit organizations, or directly with farmers to conduct studies that better define the impacts of different cultivars, nutrient, and water management practices on methane emissions.

- *Provide Financial Incentives.* Although states do not typically get involved in rice programs, states encourage the use of short-stemmed rice varieties and management practices that contribute most to reducing methane emissions through tax credits, direct payments, grants, or loans. Increased production of rice in dryland conditions can be promoted directly through subsidies.

- *Regulate Water Use*. States can restrict the amount of water allowed to be used in rice production, thus decreasing the amount of methane produced. However, requiring the use of dry upland methods or limiting water use may decrease rice yields. This policy option may be compatible with current state regulations that serve to protect surface water and ground water.

5.10 NITROUS OXIDE AND OTHER GREENHOUSE GASES FROM FERTILIZER USE

Fertilizers, whether industrially synthesized or organic (like animal manure and leguminous plant residue), add nitrogen to soils. Any nitrogen not fully utilized by agricultural crops grown in these soils undergoes natural chemical and biological transformations that can produce nitrous oxide (N_2O), a greenhouse gas.

Scientific knowledge regarding the precise nature and extent of nitrous oxide production and emissions from soils is limited. Significant uncertainties exist regarding the agricultural practices, soil properties, climatic conditions, and biogenic processes that determine how much nitrogen various crops absorb, how much remains in soils after fertilizer application, and in what ways that remaining nitrogen evolves into nitrous oxide emissions. Amid these uncertainties, the policy challenge for reducing greenhouse gases is to determine how to manipulate the nitrogen fertilizers and the time and manner in which these fertilizers are applied in order to minimize nitrous oxide emissions.

In addition to helping mitigate climate change, the policies that promote reduction of nitrous oxide emissions frequently support other state environmental and public health priorities. For example, in many cropping systems between 5% and 30% of the nitrogen applied can escape soils through leaching and water runoff, in addition to producing nitrous oxide. This fugitive nitrogen often pollutes ground water and surface water supplies. In this context, climate change mitigation policies aimed at reducing nitrogen losses to water coincide with many existing and proposed state initiatives to use fertilizers more efficiently and to reduce fertilizer use in order to protect water quality. The Iowa Agricultural Energy Management Initiative (described in Chapter 7), which was developed from the Iowa Consortium on Agriculture and Water Quality, is an example of a program that addresses improvements in nitrogen fertilizer use to enhance groundwater quality and save money in the agricultural sector, and that also decreases nitrous oxide emissions.

Technical approaches for reducing nitrous oxide emissions from fertilizers include improving nitrogen-use efficiency in fertilizer applications. Improvements mean reducing excess fertilizer application by applying only the amount crops will use, and replacing industrially-fixed nitrogen fertilizers with renewable nitrogen source fertilizers.

5.10.1 Improve Nitrogen-Use Efficiency in Fertilizer Applications

DESCRIPTION

At many sites, more fertilizer is applied than can be effectively used by crops. Further, poor fertilization timing or placement often leads to additional nitrogen loss or unavailability to the plant. One major reason for the application of excess nitrogen in the fields is the lack of simple field testing for nitrogen. Also, many farmers believe that some "excess" may be necessary to ensure peak production. This is because precise crop needs are not always known, and weather and climatic conditions that affect crop growth and nitrogen requirements are unpredictable. For these reasons, many farmers apply additional fertilizer to ensure crops have the nutrients they need.

Matching fertilizer formulation and application more precisely to the uptake needs and capacity of crops can improve nitrogen-use efficiency. Thus, matching can reduce nitrous oxide emissions by decreasing overall fertilizer consumption and by minimizing the quantity of nitrogen left in soils or sacrificed to water leaching and runoff. While the direct relationship between fertilizer application rates and nitrous oxide emissions is not well understood, current estimates suggest that better fertilization practices could reduce nitrogen fertilizer use by as much as 20 percent with low risk of yield penalty and with possible input-cost savings to farmers. However, these estimates assume an ability to project field-by-field and crop-by-crop nitrogen needs that probably exceeds existing extension, testing, and management capabilities. This highlights the primary need for further research and institutional development in this area.

CONSIDERATIONS

Seven fertilization management approaches and three specific fertilizer technologies offer opportunities for enhancing nitrogen-use efficiency. Several may be integrated into alternative agricultural systems that incorporate lower fertilizer usage and also achieve energy savings by reducing the need for plowing and other energy intensive practices.

Management approaches

- *Improve fertilizer application rate*. Matching fertilizer application with specific crop requirements would reduce excess fertilization, thus producing immediate greenhouse gas reduction benefits. Typical fertilizer application rates vary depending upon crop type, soil conditions, fertilizer pricing, and environmental policies. Better record-keeping to assess actual yields on a field by field basis can help to fine-tune fertilizer rates that are both economically and environmentally sound. Soil testing, visual inspection, or plant tissue testing could allow farmers to apply nutrients more closely following crop requirements, rather than following broad guidelines that often recommend excessive fertilization. However, efforts to provide adequate nutrition to crops may be hindered by inadequate understanding and forecasting of factors that influence nutrient storage, cycling, accessibility, uptake, and use by crops during the growing season.

- *Improve the frequency of soil testing*. Regular soil testing (*e.g.*, annual testing of all fields in production) could decrease fertilization use. Because this process can be expensive and time consuming, farmers may test soil only every two to five years. Regular soil testing to improve nitrogen management would involve new types of soil and tissue testing, such as the pre-sidedress (late spring) soil tests being calibrated in most corn belt states. Innovative technologies can assist in improving this process. For example, in Kentucky an experimental soil testing and fertilization applicator called the "Soil Doctor" tests soil nitrogen needs and automatically adjusts the fertilizer application rate accordingly. While the initial capital output for a machine like this could be high, it has been shown to decrease application rates by as much as 41 pounds per acre, a potentially significant savings to farmers.

- *Improve timing of fertilizer application*. Limited studies suggest that timing of application affects nitrous oxide emissions. For example, on a broad scale, emissions from fertilizer applied in the fall exceed those from fertilizer applied in the spring. With better understanding of these processes and their implications for crop production, fertilizer timing could be adjusted to reduce greenhouse gas emissions.

- *Improve placement of fertilizer*. Some surface placement and broadcasting of fertilizers results in excess or overlapping fertilizer application. Deep rather than surficial placement of fertilizers can curb nitrogen loss, though this may not be compatible with no-till production practices. In these practices, irrigation after fertilization could incorporate the fertilizer more deeply into the soil.

- *Switch to fertilizer compounds with lower nitrogen content.* Although nitrous oxide production rates of different fertilizers in relation to their benefits for various crops are highly uncertain, switching from fertilizers with high nitrogen content, especially anhydrous ammonia, to fertilizers with lower nitrogen content can reduce emissions, unless farmers increase fertilizer application to maintain the previous nitrogen levels. Preliminary data on nitrogen content and nitrous oxide emissions for various fertilizers are presented in the appendices to EPA's Phase I document, *States Workbook: Methodologies for Estimating Greenhouse Gas Emissions*.

- *Improve crop management for more complete nitrogen uptake*. Crop management techniques can supplement the improved fertilizer application techniques described above. For example, corn is susceptible to high rates of soil erosion because it is a row crop. After the harvest of corn, substantial amounts of nitrogen generally remain in the soil. The surplus nitrogen can be captured by inter-cropping with a grain crop such as rye, which could then be plowed back into the soil. More information on the use of organic fertilizers is presented in section 5.10.2 below.

- *Conservation tillage*. Alternative land tillage systems, such as low-till, no-till, and ridge-till reduce soil losses and associated loss of nitrogen contained in the soil. Tillage practices also affect the efficiency with which the fertilizer can be applied and incorporated into the soil.

<u>Technology approaches</u>

- *Use nitrification inhibitors*. Nitrification and urease inhibitors are fertilizer additives that can increase nitrogen-use efficiency by decreasing nitrogen loss through volatilization. Nitrification inhibitors can increase efficiency by around 30% in some situations.

- *Use fertilizer coatings*. Limiting or retarding fertilizer water solubility through supergranulation or by coating a fertilizer pellet with sulphur can double efficiency, depending on the application.

- *Reduce nitrogen release rate in fertilizers*. Techniques that limit fertilizer availability, such as slow-release or timed-release fertilizers, improve nitrogen-use efficiency by releasing nitrogen at rates that approximate crop uptake. This reduces the amount of excess nitrogen available at any given time for loss from the soil system. In addition, slow-release fertilizer can potentially decrease the number of applications, resulting in an energy and cost savings.

POLICY OPTIONS

Farmers may pursue proven and familiar fertilization practices without understanding the negative environmental impact of excess nitrogen application or potential benefits of reducing commercial nitrogen use. Concurrently, scientific and technological uncertainty inhibits program development in this field. In this sector, policy options are generally oriented around these two barriers to nitrous oxide emission reduction.

The types of policy options listed below can be combined and integrated in a variety of ways to control nitrous oxide emissions. For example, educational and agricultural support programs for farmers in combination with financial or regulatory incentives applied to specific fertilizers may be an effective comprehensive mechanism for encouraging better nitrogen-use efficiency.

- *Provide Information.* Through educational programs or farming and technology demonstration projects, states can communicate to farmers critical information on fertilizer use and farm management practices. Farmers' lack of basic information on nitrogen processes in soils is frequently cited as a major barrier to nitrous oxide reductions. Education programs can target efficient fertilizer use, with particular attention to appropriate application rates based on realistic yield expectation, monitoring of nitrogen levels, and effective application techniques. These programs help address barriers posed by the "insurance value" to farmers of high fertilizer use levels, as well as by farmer habit and tradition. However, states should be cautious about advocating farming techniques and fertilization practices that are surrounded by high levels of scientific uncertainty.

- *Provide Institutional Support.* The Extension Service is an additional means of providing adequate and accessible technical capability for determining precise fertilizer needs by crop type, soil characteristics, moisture, weather, and other variables. For example, states could encourage the use of the soil testing services provided through land grant colleges and extension services by decreasing fees, increasing farmer awareness of the programs, or increasing farmer awareness of fertilization cost savings associated with annual soil testing. Again, however, certainty regarding farming practices to reduce greenhouse gas emissions and maintain crop productivity is limited at the current time.

- *Support Research and Development.* Little field research is being conducted on nitrous oxide emissions from fertilizers in the United States. Many of the technological approaches presented above have not been tested extensively. Research in this area is generally expensive because it is labor- and/or equipment-intensive.

- *Provide Financial Incentives.* Low prices for fertilizers, especially in states where fertilizer subsidies exist, cause excess consumption and nitrogen application. States may be able to revise fertilizer and crop subsidy structures to curb the use of nitrogen-intensive fertilizers or the growth of nitrogen-intensive crops. Similarly, state programs may levy taxes or other price increases to encourage farmers to better monitor and reduce nitrogen application. A few states have also imposed fees on fertilizers to support research and education programs, although these fees are not intended to be nor are they considered large enough to directly affect fertilizer demand. This type of policy may conflict with some state policy goals (such as support of the agricultural sector), while complementing others (like surface and ground water protection).

- *Regulate Fertilizer Use and Production.* Regulating fertilizer application rates and practices is difficult due to the lack of substantial evidence regarding the greenhouse gas benefits and to side effects on crop production. These uncertainties could increase political sensitivities surrounding this issue. In addition, difficulties surround widespread enforcement of the regulation at farm sites. However, regulating nitrogen content in synthetic fertilizers may aid reduction of nitrogen consumption, particularly if accompanied by education and information programs for farmers.

5.10.2 Replace Industrially-Fixed Nitrogen Based Fertilizers with Renewable Nitrogen Source Fertilizers

DESCRIPTION

Animal manures, as discussed in Section 5.12, and leguminous crops are potential organic nitrogen fertilizers. Traditional crop rotation, dual-cropping or inter-cropping, for example, involves rotating lands under cultivation with legumes (such as alfalfa and soybeans) in order to store nitrogen in soils, as an alternative to synthetic fertilizer use. Current data suggest that direct nitrous oxide emissions from organic process uses may be as high or higher than from synthetic fertilizers. In an overall greenhouse gas context, however, replacing industrially-fixed nitrogen based fertilizers with renewable nitrogen source fertilizers may still help reduce comprehensive greenhouse gas emissions in two ways:

1) Organic fertilizers can be used to replace synthetic nitrogen fertilizers where both are currently applied. In current agricultural systems, farmers frequently do not consider the nitrogen content of the organic fertilizers they apply. In these situations, they add additional synthetic fertilizers, resulting in excess levels of nitrogen in soils. Nitrous oxide reductions would occur if farmers took full advantage of organic fertilizers and only used synthetic fertilizers when needed as a supplement. To adhere to this process, farmers must know and understand the nitrogen value of the organic fertilizers. Benefits from this approach would accrue immediately upon reduction of excessive nitrogen application in soils.

2) Using organic fertilizers can conserve significant amounts of energy that would have gone into synthetic fertilizer production. Aside from direct nitrous oxide emissions, energy savings from reducing production of high-energy industrially-fixed nitrogen based fertilizers will result in decreased greenhouse gas emissions. The 1991 report of the Missouri Commission on Global Climate Change & Ozone Depletion suggested that it would be "prudent to use livestock wastes as fertilizer rather than incurring the costs of waste treatment and using additional energy to produce chemical fertilizers and causing greenhouse gas emissions." Quantification of nitrous oxide emissions from organic fertilizers per unit of nitrogen supplied to the soil is required to make this determination, as current estimates of nitrous oxide emissions from these sources cover a wide range. The emission reduction benefits from this type of program may be difficult to quantify, and would not accrue until currently active synthetic fertilizer plants ceased production.

CONSIDERATIONS

The most likely renewable fertilizer for replacing synthetic fertilizer is manure. This may cause shortages of manure in areas where manures are productively applied to other uses, while it may help alleviate manure and waste management problems in other locations. Economical ways or incentives are needed to distribute manure to areas where it can be beneficially used. Such programs have sometimes been discussed as manure brokering, arranging exchanges among farms to transport the excess manure to a farm that can advantageously and economically utilize it as a nutrient source. Similarly, in programs where farmers may come to rely on organic fertilizer use, it would be necessary to guarantee a constant and dependable fertilizer supply from the renewable sources.

The scientific uncertainty regarding nitrogen uptake from renewable fertilizer sources also makes it difficult to develop renewable fertilizer programs. Programs that both help farmers accurately assess the needs of their crops and provide reliable information on the nitrogen replacement value of renewable fertilizers seem most promising.

Broad guidelines, based on the solids content and source of manure, have been designed in Wisconsin and Michigan to determine the nitrogen, phosphorous, and potassium levels of manure. Using these guidelines in experiments in Minnesota, manure has been shown to be a sufficient fertilizer for alfalfa. Likewise, some dairy farmers in Georgia have used manure for several years to produce both corn and wheat. In addition, experiments in Minnesota have demonstrated that the use of either manure or leguminous crops, in rotation and plowed under, can increase the dry matter content of the crops grown. This could be advantageous to dairy and cattle farmers, because increases in dry matter content can increase feed efficiency.

POLICY OPTIONS

Potential policy mechanisms for promoting the use of renewable fertilizers are similar to those presented in Section 5.10.1 above. The same policy approaches, especially research programs and farmer education and extension services, could be crafted to encourage a switch from industrially based fertilizers to organic ones. For example, improved methods for determining the fertilization quality and the application of manure could be developed. Similarly, broad subsidy or tax programs, or regulation of fertilizer production could provide additional incentives for renewable fertilizer use.

5.11 EMISSIONS ASSOCIATED WITH FORESTED LANDS

Trees and other vegetation remove, or sequester, carbon dioxide from the atmosphere as they grow, storing it as carbon in trunks, limbs, roots, and soil. Through this process, forests provide an important terrestrial "sink" for carbon dioxide. Furthermore, wood products are relatively long-lived structures that store carbon, which makes up about half the dry weight of wood, rather than allowing it to be released back to the atmosphere. Forest-related land use changes can affect the concentration of greenhouse gases in a number of ways.

- *Forest Clearing by Burning* results in immediate emissions of CO_2 and other by-products of combustion, such as CO, CH_4, and N_2O. While CO_2 will later be sequestered during regrowth, emissions of these other combustion by-products (which can include N_2O and methane) represent a net increase to the atmosphere.

- *Forest Regeneration* will, over time, result in uptake of CO_2. The net impact of forest clearing on emissions depends on whether the forest regrows to its original level of biomass density (*i.e.*, the quantity of biomass per unit of land area).

- *Conversion of Forests to Other Land Uses* can result in net emissions of CO_2 because land uses such as crops, pastures, or suburban development sequester and store less carbon than do forests.

- *Mechanical Forest Clearing* changes the emissions profile of CO_2 and other by-products of decay, such as methane. The magnitude and timing of these emissions depend on the fate of the biomass (*e.g.*, whether it is left on-site to decay or used for longer-lived wood products).

- *Disturbance of Forest Soils* can lead to CO_2 emissions as organic material in soils is oxidized. Losses of nitrogen, possibly in the form of N_2O, are also thought to occur. Some data indicate that conversion of forest land to other vegetative uses diminishes the capacity of soils to absorb methane, thus potentially increasing atmospheric methane levels.

Approximately 59 percent of timberland in the U.S. is owned by nonindustrial private forest owners, 27 percent is publicly owned, and 14 percent is owned by the forest industry (RPAA, 1990).[22] Much of the publicly owned forest land is controlled federally through the U.S. Forest Service (USFS), the National Park Service, the Bureau of Land Management (BLM) and the Department of Defense. While the ability of states to affect the use of federal forest land may be limited, states can play a key role in affecting the use of both privately owned and state owned forests within their borders. Opportunities for state action described in this section are not mutually exclusive and frequently offer other significant benefits, such as increased timber productivity, reduced soil erosion, improved water quality, increased biodiversity, improved fish and wildlife habitat, and recreational opportunities.

This section presents five basic technical approaches to controlling emissions of greenhouse gases associated with forested land. The first approach addresses maintaining the carbon storage capacity of existing forested lands. The second addresses opportunities for enhancing the long-term potential to sequester carbon in existing forests through increases in productivity. The third and fourth suggest that climate change issues be integrated into state strategies for fire management and pest control, respectively. The final approach addresses policies that affect the demand for forest products.

5.11.1 Maintain Carbon Storage Capacity of Existing Forests

DESCRIPTION

During the past 25 years, the United States has maintained a relatively stable area of forest land. (EQ, 1995). If forests were being converted to other uses with lower biomass densities, there would be a reduction in carbon sequestration, since the carbon stored in vegetation and soil is greater for forested lands than for alternative land uses (such as crops, pastures, or commercial and suburban development). Therefore, maintaining existing forest and timberland can significantly contribute to stabilizing carbon sinks.

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[22] Two-thirds of the Nation's forests (490 million acres) are classified as timberlands. Timberlands are defined as forests capable of producing 20 cubic feet per acre of industrial wood annually and not reserved from timber harvest. An additional 36 million acres is reserved from harvesting and is managed as parks or wilderness. Total forest land in the U.S. for 1992 was approximately 737 million acres, of which the USFS owned 19 percent, the BLM 5 percent, other federal agencies 18 percent, and non-federal entities 66 percent.

State policy-makers may be able to maintain existing forests to preserve forest carbon sinks by:

- Slowing or stopping the conversion of forested lands to less-biomass dense, non-forest land uses;

- Ensuring, for forest lands where timber harvests do occur, that replanting occurs to replace the carbon sequestration potential of the harvested forest;[23] and

- Ensuring, for extremely carbon-dense forests (*e.g.*, some old growth forests) where replanting may not offer the same level of carbon-density, that harvesting does not occur and the land is preserved as a set-aside.

In addition, while there is considerable uncertainty about the net effects of logging on long-term soil carbon emissions, logging can cause soil erosion which may contaminate water supplies, disrupt wildlife habitat, and deplete aesthetic value of the forest. Because of these concerns and the possible climate change benefits, states may find it desirable to undertake policies to minimize soil erosion in existing forests.

CONSIDERATIONS

Whether maintaining a specific forest ultimately reduces net emissions of carbon depends on the potential for change in its biomass density. Halting conversion of forests to non-forest land uses almost certainly will provide significant benefits because alternative land uses store considerably less carbon than do forests.

It is important to remember, however, that if over the long run harvested lands are replanted or allowed to regrow with trees of similar carbon content and to a similar biomass density, net cumulative emissions may be close to zero. Determining the emissions reduction value of policies targeted at timber harvesting on lands that remain dedicated to forestry therefore requires a case-by-case assessment.

The carbon benefits of maintaining existing forests will vary by region and species. For example, forests of the Pacific Coast states, comprised principally of Douglas fir, contain on average 102 tons of carbon per acre, while forests of the South Central region of the country, primarily oak-hickory forests, contain an average of 58 tons per acre (Birdsey, 1991). In addition, state policy-makers will need to characterize the process of reforestation (either natural or assisted) and assess whether new growth timber will offer the same carbon sequestration capacity as the existing forest.

Halting all timber harvests in certain forests, such as old growth forests, may yield carbon reduction benefits because these forests tend to have greater biomass densities and therefore store greater amounts of carbon than do the younger, secondary, forests that may replace them. The effectiveness of halting old growth timber harvesting in lieu of converting old-growth to secondary growth, in terms of carbon storage potential is, however, subject to some debate (Harmon, et al., 1990). Further, the uses for harvested material may themselves provide a carbon pool, as in the case of long-lived wood products, such as furniture or construction.

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[23] Because of the potential to offset carbon emissions from any source, opportunities to create newly forested areas are described in Chapter 6 as a cross-cutting policy option.

State policy-makers should also consider that the net change in the carbon pool over time depends on the extent to which reduced harvests are offset by increased harvests elsewhere. For example, even if net carbon dioxide emissions from U.S. forest land may be reduced by harvesting restrictions, global carbon dioxide emissions from logging may remain the same or perhaps even increase if the demand for wood products does not change. Policy-makers should carefully weigh these issues when evaluating alternative policy options.

As noted above, efforts to control soil erosion may yield multiple environmental benefits. Federal water pollution control statutes have been a major impetus behind state efforts to control timber harvesting activities near streams. State controls range from voluntary compliance with guidelines developed as "best management practices" to mandatory legal restrictions. For example, states may require that roads be constructed away from stream banks, that cross drainage be provided for roads with significant slope, that erosion control bars be installed throughout a site, and that roads or adjacent areas be seeded after harvesting. In addition, since clear cutting is associated with significantly more soil erosion than selective harvesting, some states have restricted its use.

Reduced timber harvesting, reforestation requirements, and forest management standards may create unwanted economic impacts. Without a decrease in demand for forest products, harvest restrictions may result in higher wood prices and lower levels of production. Given this potential consequence, states in which forestry is a leading industry are unlikely to have the political support to significantly restrict harvesting, though less costly forest management measures may find support. In addition, harvest restrictions may reduce revenues to state and local governments from lease payments and taxes on timber production.

POLICY OPTIONS

- *Support Research and Development*. States may support or conduct forest carbon life cycle analysis to resolve the debate on carbon benefits of forest set-asides and on the change in carbon sequestration capacity associated with harvesting and subsequent reforestation. Such studies could be conducted on a regional basis, considering species composition, and physiographic and climatic features of the region, as well as economic issues, where appropriate.

- *Provide Financial Incentives*. States can offer private owners of forest land incentives to keep their lands out of production, to employ best management practices, or to encourage prompt efforts at reforestation.[24] In North Dakota, the Woodland Tax law provides tax relief for landowners who agree to prohibit clear cutting, grazing, burning, and destructive cutting on woodlands. Similarly, the State of Missouri provides tax relief to land owners who agree to maintain property as forest cropland.

- *Control Development.* Some states have issued tradeable property allowances for privately owned forest areas that they wish to preserve. For example, New Jersey has been successful in capping development in the Pine Barrens through this type of system (Task, 1991). In addition, state and local governments may be able to use their land use planning authorities to restrict the conversion of forested lands to other land uses. States could also establish a fund for forest land purchase and subsequent set-asides.

[24] Chapter 6 provides additional information on options for encouraging the planting of trees.

- *Promulgate Regulations.* States may limit the amount of timber that may be removed from a given site, specify logging practices, or impose reforestation and best management requirements. States can do so either with a permit system or as part of lease provisions for timber harvests on public lands. States could also require that least cost planning that incorporates environmental benefits be conducted for timber harvests on state lands.

- *Monitor Forests.* Some states monitor private industry implementation of best management practices, particularly at timber stands near streams. Florida monitors these harvests by air, targeting counties where foresters fail to use best management practices for increased technical assistance.

- *Address Institutional Barriers*. States should recognize that, in areas where local economies are heavily dependent on timber production, state and local policy-makers often exert significant pressure on field managers of federal forest lands to maintain harvests, perhaps at unsustainable levels. States may wish to consider whether such pressures might undermine the goals of their climate change policies.

5.11.2 Improve Productivity of Existing Forest Lands

DESCRIPTION

By increasing the productivity of forest species, demand for forest products could be met with fewer trees extracted, less carbon released to the atmosphere, and potentially more carbon sequestered. Management approaches that can be used to improve timber stand productivity and carbon sequestration include: thinning trees to decrease competition and stocking additional trees to achieve optimal forest density, planting or replanting unstocked timberland, and enhancing planting sites by providing drainage and/or adding fertilizer. The USFS estimates that if current commercial forests were fully stocked, their net annual growth could increase by about 65 percent. These techniques have been extensively researched and are readily available.

In addition, the use of improved seed stock from cross-breeding or genetic manipulation can enhance productivity. The USFS credits genetic improvements in seed stock, achieved primarily through plant breeding and silvicultural techniques, with substantial increases in annual tree growth in southern conifers.

Wood utilization technology is also being developed by the forest industry and the federal government to meet the demand for wood products with low value, previously underutilized timber. Doing so may mean that less wood residue is left on the forest floor or discarded at the mill to decay. The carbon benefits derived from improved wood utilization depend upon the degree to which such utilization allows for reduced harvests of virgin timber.

CONSIDERATIONS

Several federal and state programs encourage improved forest management. The principal federal programs are the Cooperative Forestry Assistance Program and the Federal Incentives Program (FIP). The Cooperative Forestry Assistance Act of 1978 authorizes federal financial and technical assistance to state forestry agencies for nursery production and tree improvement programs, reforestation and timber stand improvement activities on nonfederal lands, protection and improvement of watersheds, and programs to provide technical assistance to private landowners and others.

FIP authorizes cost-share payments for reforestation and timber stand improvement, site preparation for natural regeneration, and firebreak construction. FIP is jointly administered by the U.S. Forest Service and the Agricultural Stabilization and Conservation Service within the U.S. Department of Agriculture. A number of states also have cost share programs similar to FIP. In addition, the Cooperative Extension Service has traditionally been the primary channel for disseminating new research findings to forestry professionals and landowners.

While public timberland is generally intensively managed, most nonindustrial timberland is not. Various studies identify a number of reasons why nonindustrial timberland owners may not manage their forests for higher productivity. First, many landowners are not aware of what can be done to improve forest growth. Second, among those who are aware of the opportunities, many may be unwilling to undertake projects with a long payback period or relatively modest rates of return. Third, many lack the up-front capital needed to invest in a crop that, although profitable, may not generate income for 10 to 15 years. Additionally, landowners may resist investing in improving their forested land because of the low financial liquidity of young stands and an inability to use future forest values as collateral. Last, some landowners use their timberland for other purposes, such as recreation, which do not require high productivity.

Not all timber stand improvement practices support the goal of reducing greenhouse gas emissions or other environmental goals. For example, increased use of nitrogen-based fertilizer in forests could increase direct emissions of nitrous oxide (a greenhouse gas), cause ground and surface water contamination from its application, produce carbon dioxide emissions from its manufacture, and lead to soil methane emissions, by slowing the activity of methane consuming bacteria acting at the soil surface. Intensive management disturbs forest soil which may increase soil erosion and thus reduce water quality. Also, methods such as stand thinning expose the forest floor to more light, increasing soil surface temperature and accelerating decomposition which liberates carbon.

In contrast to timber stand improvement techniques, some seed stock improvement techniques are currently unavailable for widespread use. For example, while cross-breeding is widely used, genetic manipulation for tree improvement is still in its infancy. Like certain stand improvement techniques, some uses of genetically improved seed stock may also work against the goal of increasing carbon sequestration and storage. Monoculture plantings, for example, lack biodiversity and may be more susceptible to factors, such as pestilence and disease, that reduce forest health and long term carbon storage potential.

POLICY OPTIONS

- *Provide Information and Technical Assistance*. States may disseminate information on the multiple benefits of improved productivity in conjunction with the Cooperative Extension Service. State foresters could act as the clearinghouse for new developments in timber stand and tree improvement techniques or provide direct technical assistance to private landowners on how to manage their forests to achieve a variety of objectives. Presently, some states have initiated forest management and seed stock improvement demonstration projects.

- *Support Research and Development*. States could support research laboratories for research and development in stand improvement techniques, tree breeding techniques, and seed stock, that would be particularly appropriate for use in the state and private forests within their jurisdictions.

- *Provide Financial Incentives*. States could also provide tax incentives to private landowners and forest industry to improve productivity through timber stocking or other methods. Direct payments, tax incentives, and loans could be used to provide encouragement to nonindustrial owners of private timberlands to improve forest management and breeding techniques, or to encourage the testing and use of new seed stock. Some states may be able to implement cost-sharing programs modeled after FIP.

5.11.3 Integrate Climate Change Concerns into Fire Management Policies

DESCRIPTION

Carbon stored in biomass is released upon combustion during forest fire. Soil carbon is liberated both during and after fire disturbance. Some of the forest carbon lost is recaptured during the rapid regeneration of plants following wildfire. However, the direct and post-fire soil carbon emissions from wildfire are thought to outweigh the carbon sequestered by regrowth. Wildfire burned more than 5 million acres of U.S. forest land in 1990; forty-five percent of this land was state and privately-owned forests (USDA, 1992).

A state's fire management strategy is likely to address multiple concerns in addition to the potential for carbon emissions. Such concerns include protection of life and property, conservation of valuable timber, preservation of species habitat, air quality issues, and maintenance of recreational areas, as well as a countervailing concern that wildfire can serve an important ecological benefit by clearing the land of dead and diseased vegetation and allowing opportunities for new growth. Because of the significance and importance of these other considerations, it is suggested here only that the impact of forest fires on climate change be considered when developing state fire management policies.

CONSIDERATIONS

Two principal fire management strategies can be employed to reduce carbon emissions from fire, including:

- *Active fire suppression* -- which halts direct carbon emissions. Some research, however, suggests that fire suppression results in an accumulation of dead and dying timber on the forest floor and a greater fire risk. Fire management by suppression may also affect species composition, particularly of fire adapted forest communities.

- *Controlled or "prescribed" burning* -- which contributes to direct carbon emissions in the short term, but reduces fuel accumulated on the forest floor and may prevent or lessen the extent and intensity of future wildfires. Prescribed burning also fosters goals to improve wildlife habitat, and eradicate forest disease and pests.

More research on fire management is required to determine which strategy or combination of strategies is best for minimizing carbon emissions over the long term. Some consideration must be given to the fact that fires, in addition to liberating carbon, also liberate particulates and other air pollutants. States may want to consider the climate, physiography, forest species composition, and air quality within their jurisdictions to assess the optimal fire management strategy.

POLICY OPTIONS

- *Support Research and Development*. States could undertake studies of fire patterns in forests in their jurisdictions to assess strategies for optimizing carbon storage in coordination with other forest management goals.

- *Inter-Agency Cooperation*. State policy-makers responsible for climate change issues may work with fire officials to ensure that climate change issues are reflected in fire management decisions.

5.11.4 Integrate Climate Change Concerns into Pest Management Policies

DESCRIPTION

Forest insects and diseases attack tree foliage, bark, and woody biomass, eventually killing trees. Downed trees are decomposed by microorganisms and in the process biomass carbon is eventually returned to the atmosphere as either carbon dioxide or methane. Because of the threat to valuable timber and to agricultural operations, virtually all states already have some form of pest management program. Because minimizing the impact of pests and diseases on existing forest land helps enhance carbon storage potential as well as reduce emissions from biomass decay, it may prove useful to integrate climate change concerns into pest management policies.

CONSIDERATIONS

Several methods can be used to check the development or spread of forest pests and disease. Prescribed fire, chemical controls, biological controls, and salvage clearing have all been used successfully in forest ecosystems. Although they contribute to reducing forest losses, each of these controls may have long term impacts on the integrity of the ecosystem. For some infestations, none of these control methods is successful. More research is required to find appropriate control methods for unmanageable forest pests and disease.

The Forest Health Monitoring Program, jointly administered by the USFS, the Bureau of Land Management, and EPA, provides assistance to state foresters in monitoring disease and insect infestation in state forests. In addition, most states routinely monitor forest health and provide assistance to private landowners and state land managers for the control of pests, such as training on tree health and on the effects of environmental stress on trees.

POLICY OPTIONS

Pest management policies must be tailored to the specific species composition, climatic, and geographic conditions of the forest in which they are implemented. Policy options in this area include the following:

- *Provide Information*. Many states work jointly with the Cooperative Extension Service to provide information to private landowners on methods to prevent and reduce forest pestilence and disease.

In addition, forest health demonstration projects may be sponsored by some states. States may also supply pest and disease resistant seed stock to landowners.

- *Provide Financial Incentives*. States may help develop a market for timber salvaged from private forests and provide incentives for monitoring pest incidence and downed timber on forest lands.

5.11.5 Institute Policies to Affect Demand for Forest Products

States may be able to reduce emissions associated with forested lands by pursuing policies that do not directly affect forest land but that instead focus on the demand for forest products. This section addresses three options for implementing this approach. The first addresses opportunities to improve the efficiency of wood burning to reduce the demand for fuelwood. The second focuses on policies to encourage the use of long lived durable wood products. The third addresses recycling of paper products to reduce demand for timber.

Improve Wood Burning Efficiency

DESCRIPTION AND CONSIDERATIONS

Wood can be used as a direct source of heat for homes and small buildings or as a source of electric power. In addition to producing carbon dioxide, wood combustion produces particulates, nitrous oxides, sulfur dioxide, and carbon monoxide. Improvements in wood combustion efficiency can reduce fuelwood consumption and decrease carbon dioxide emissions, emissions of other pollutants, and ash accumulation. For large scale wood combustion facilities, emissions of non-carbon pollutants can be mitigated by a combination of improved combustion efficiency and air pollution control devices.

POLICY OPTIONS

States can employ several policies to encourage more efficient wood burning. These include the following:

- *Provide Information and Education.* States may educate residents and businesses on technologies available to increase wood combustion efficiency.

- *Support Research and Development.* New technologies, such as high efficiency wood stoves for home heating, combust fuelwood more completely and reduce fuelwood consumption relative to less efficient wood stoves. States can support the development of wood combustion efficiency technology for both residential and commercial users of fuelwood.

- *Promulgate Regulations.* States may establish technology-based standards for wood burning stoves. Alternatively, states may restrict fuel consumption or limit allowable pollutant emissions in order to control greenhouse gas emissions from wood burning and to encourage improvements in wood burning technology. For example, for large scale wood combustion facilities that produce more than 1 million Btu per hour, New York State requires air permits that limit the allowable emissions for each pollutant, including carbon dioxide.

Encourage the Use of Durable Wood Products

DESCRIPTION

The potential for forests and forest products to absorb and store carbon dioxide can be expanded by increasing the use of timber products as construction materials, furniture, and other durable wood products, which continue to store the wood carbon after harvest. Carbon contained in wood products may remain for several decades before returning to the atmosphere through decomposition or burning. Some research indicates that the average life and, therefore, duration of carbon storage for certain wood construction materials is approximately 70 years (Row and Phelps, 1991). Particularly if the timber harvest used for these products comes from afforested or reforested lands, rather than depleting existing stands, the aggregate carbon pool may be expanded. Switching from non-renewable construction products -- many of which are energy intensive in their production, such as steel -- can also reduce carbon dioxide emissions by reducing energy consumption.

CONSIDERATIONS

Timber is used for a variety of products, including lumber, structural and non-structural panels, pulpwood, silvichemicals, fuelwood, and other miscellaneous industrial products, such as poles and piling, posts, and mine timber. A large portion of the total timber harvest, about 38 percent, is used to produce lumber, and 27 percent is used in pulp (including paper) products. U.S. consumption of timber has increased steadily over the past three decades, from about 12 billion cubic feet in the early 1950s to 20 billion cubic feet in 1988.

Because the trees that are planted may eventually be harvested and release their stored carbon, timber end-use can be an important component in increasing long-term sequestration. Wood end-uses that are most relevant to long term carbon storage include new residential and commercial building materials, materials for building repair and remodelling, and material for furniture, cabinets, and fixtures. Increased use of these durable wood products can offset carbon emissions both by promoting a sink for carbon and by substituting timber for energy intensive construction materials.

The use of durable wood products can be expanded in several ways:

- By encouraging longer tree rotations, which yield timber that can more easily be converted into durable wood products;

- By encouraging the demand for durable wood products, through price or other incentives; and

- By encouraging the supply of durable wood products directly.

Because wood cannot be substituted for non-wood products used in construction on a one-for-one basis, feasibility constraints may reduce achievable carbon savings or limit the applicability of substitutions. In addition, state policy-makers need to take a broad view of the potential costs and benefits of efforts to encourage the use of durable wood products. Key considerations include: regrowth of the forest's original biomass density; the energy related emissions associated with harvesting, transporting, and using the wood product; and the emissions associated with production and use of the non-wood product being replaced.

POLICY OPTIONS

Several policy options are available to encourage either the supply of or the demand for durable wood products.

- *Provide Information.* States can encourage the production and use of durable wood products by disseminating information on the carbon benefits of their use, or by assisting local governments in examining alternative specifications for building codes.

- *Support Research and Development.* States can support research to develop wood-utilization technologies or forestry methods that reduce the cost of producing timber for durable products. States can also study the extent to which wood can be substituted for non-wood products, with an emphasis on its cost and technical feasibility and on the associated change in total greenhouse gas emissions.

- *Provide Appropriate Financial Incentives.* Financial incentives promote both the supply and the demand for durable wood products. Potential incentives include tax credits for the production and/or use of durable wood products, energy or carbon taxes to raise the relative price of energy-intensive construction materials, and timber subsidies to encourage longer harvest rotation periods.

Encourage Paper Recycling and Recycled Paper Use

By replacing virgin fiber sources with wastepaper, recycling has the potential to reduce net carbon emissions by reducing levels of timber harvesting. Ultimately, the amount of carbon that can be sequestered depends critically on the effects recycling has on both planting and harvest decisions and, thus, on timber inventories as a whole. Because paper and paperboard products currently account for 32 percent of the municipal solid waste stream and contribute to methane formation, recycling may relieve some of the pressures of solid waste disposal on landfill space (U.S. EPA, 1993a). Policy options for encouraging recycling are presented in full detail in Section 5.6.

5.12 GREENHOUSE GASES FROM BURNING OF AGRICULTURAL WASTES

Large quantities of agricultural crop wastes (such as straw, stubble, leaves, husks, and vines) are produced from farming systems. In preparation for each cropping cycle, this waste must be eliminated. This is most often done through open field burning, which increases the field's production capacity by releasing nutrients into the soil, eliminating troublesome weeds and diseases, and removing dead material which may block sunlight or impede crop growth. The burning of agricultural crop wastes, however, also results in significant emissions of CH_4, CO, NO_x, and N_2O.[25] Emissions reductions from this source can be achieved through the disposal of agricultural waste through alternatives to burning.

Previous concern over agricultural waste burning has focused primarily on emissions of particulate matter rather than greenhouse gases. To control particulate emissions as regulated under the *Clean Air Act* (CAA), some states have instituted smoke management programs. These programs are generally administered by state health, environmental, or air quality agencies, or a consortium of agencies.

[25] Burning of crop residues is not thought to be a net source of carbon dioxide (CO_2) because the carbon released to the atmosphere during burning is reabsorbed during the next growing season.

Because agricultural crop waste burning is uncommon in many parts of the U.S., little federal action has been taken in this area. Under the CAA, biomass burning is regulated to the extent that it affects air quality standards. Beyond that, reducing the burning of residues has primarily been a state concern. Recently some areas have set limits on the burning of agricultural crop wastes, particularly in the Pacific Northwest. For example, Oregon has passed legislation to gradually phase-down the burning of agricultural residues until 1998, at which time the maximum number of acres which can be burnt will be set at 40,000 (an 80 percent reduction from current levels) (Oregon, 1990).

The viability of any burning alternative depends on several factors, including: 1) its ability to meet the same objectives that prescribed burning accomplishes, 2) economic competitiveness with prescribed burning, and 3) technical feasibility. Options available for reducing emissions in this area include plowing residues back into the soil, removing crop residues for other uses, using alternative burning techniques, and replacing with alternative crops.

5.12.1 Plow Residue Back Into Soil

DESCRIPTION

One option for returning nutrients to the soil without burning is plowing the agricultural wastes back into the field. For example, plowing corn husks back into the field will enhance soil quality, which is one of the primary objectives of open field burning. This method is limited, however, because many crops are perennial. Such crops, like rye grass, will continue to live and produce over several seasons and therefore cannot be plowed for several years. An alternative is slot-mulching, where slots are carved throughout the field and farmers incorporate as much residue as possible into these slots.

CONSIDERATIONS

The potential for the incorporation of crop residues into the soil as a burning alternative is limited primarily by economics, lack of adequate pest and disease control, and decomposition rate. The relative importance of these factors varies with crop type and geographic location. For example, California straw is not readily degradable, whereas rice straw in the southern rice belt rapidly decomposes. Straw decomposition rates can vary even among soil series within individual states. In general, high straw yields, dense clay soils, and wet environments are not conducive to straw decomposition. Improvements in straw choppers can help overcome such adverse conditions.

Another potential problem with soil incorporation is pest, disease, and weed control. Soil incorporation of weed seeds increases the need for weed control treatments, and can jeopardize product quality in the marketplace. In cases where stem rot disease is a problem, continued plowing under often results in substantial yield reductions (U.S. EPA, 1992b).

POLICY OPTIONS

- *Support Research and Development*. Additional field research on the benefits of crop residue soil incorporation is needed before widespread acceptance can be expected.

- *Provide Information*. States can disseminate more information describing the soil benefits achieved with this practice, effective use, and optimal situations. In doing so states may use resources such as USDA's Soil Conservation Service and the Cooperative Extension Service.

- *Provide Financial Incentives*. States could also implement a fee structure to encourage the use of emissions reduction techniques and alternatives to burning. For example, states may establish the use of registration fees ($/acre burned) or emissions fees ($/ton emitted).

- *Establish Legal Limits*. States can also limit the amount of acres burned through legislation. For example, Oregon currently sets the maximum acreage that can be burned at 250,000 acres per year (U.S. EPA, 1992b). In addition, a state may elect to restrict the time of year when burning can be conducted or prohibit certain types of burning during historical seasons of nonattainment (with respect to particulate emissions). Washington and Idaho are additional examples of states that have set restrictions on burning, specifying when residues can be burned as a function of meteorological conditions and other constraining factors. Specifying the time when residues can be burned will reduce emissions only when such restrictions reduce the quantity of the residues burned. Greenhouse gas emissions occur regardless of the time the residues are burned.

5.12.2 Remove Crop Residues and Develop Alternative Uses

DESCRIPTION

Historically, it has been difficult for grass straw to compete in existing markets as a raw material resource. Low bulk density of the straw (which requires costly densification), high transportation costs, uncertainty of long-term supply, and low volume of supply in fiber markets have usually made straw non-competitive with other raw materials, particularly wood wastes (U.S. EPA, 1992b).

The potential usefulness of agricultural waste includes not only composting prior to reapplication to the soil but other uses such as alternative (biomass) fuels or building materials. Such applications require the mechanical removal of residues from the field. While compliance with some commodity support programs may prohibit this removal, if no conflicts or restrictions exist the crop residues can be used and marketed in a variety of ways.

Composting. Composting involves gathering agricultural wastes and setting them aside to decompose. Residue collection methods with this application include raking, residue flail-chopping, and vacuuming into sacks with soil and nitrogen sources such as chicken manure, and crew-cutting. After the waste has decomposed, the decayed material can either be marketed or returned to the soil as fertilizer.

Supplemental Feed Market. Agricultural crop wastes such as grass straw can be collected and sold in a supplemental feed market. The straw must be gathered, baled, stored, and compressed so that it can be shipped on order. This practice is currently one of Oregon's primary alternatives to burning. Approximately 150,000 - 250,00 tons of straw are shipped to Japan each year (Britton, 1992). Untreated straw makes for poor quality livestock feed because of low protein and high fiber content. With appropriate treatment (*e.g.*, ammoniation), the digestibility and palatability of straw can be increased substantially, making straw a potential component of maintenance diets for ruminant livestock.

Alternative Fuel Source. Agricultural residues can be used as an alternative (biomass) fuel source for cooking, space heating, drying of agricultural products, and the production of power by steam engines or Stirling motors (Strehler and Stützle, 1987). Specific applications include burning the residues in furnaces to generate heat for drying units or for space heating at home. There is tremendous potential for improving the end-use efficiency in such energy conversion processes (Lashof and Tirpak, 1990). Biomass fuels can also be used to produce motive power or electricity by using a steam engine, a Stirling motor, or a gasifier. Gasifiers can convert agricultural residues from solid fuel into gasified fuel. They have been used to provide electricity and to power tractors and irrigation pumps. In all of these applications it is important to use biomass with a relatively low moisture content; otherwise, the energy loss due to water vaporization will be too high.

Paper and wood product substitution. Agricultural residues can also be used for non-energy purposes. For example, residues can be gathered for fiber or building materials. Weyerhauser, a paper and lumber company, is investigating the possibility of using agricultural residues as filler in particle boards.

CONSIDERATIONS

Composting can be relatively time-consuming compared to burning. The level of effort necessary for a productive program depends on several factors, including decomposition rates and weather and moisture conditions. Also, the process of large-scale composting is not fully understood or refined. The Agricultural Research Service (ARS) in Corvallis, Oregon, is researching the effectiveness of low-input composting and ideal composting procedures. The USDA/ARS in Beltsville has had a successful research program in large-scale composting and developed the Beltsville Aerated Rapid Composting (BARC) method, currently in use at the WSSC Calverton Composting Facility.

Marketing straw in the United States may be more difficult than in foreign markets due to the erratic and competitive nature of U.S. markets. For example, supplemental feed markets may only be a profitable option if a drought occurs with a significant impact on crop yields, forcing the price of feed and other agricultural products to rise. Furthermore, any physical and chemical treatments to enhance the quality of the straw will increase the cost of this alternative. Finally, because Japan can obtain straw from other countries such as Australia or Argentina, it may not prove to be a reliable customer for U.S. sources.

Combustion for heat generation may be the most appropriate means of replacing fuel oil with residues, because much less investment is necessary compared to replacing fuel oil in power generation. Also, the total maximum efficiency of the power produced by means of a turbine or steam engine is approximately 15 percent, even though the combustion of biomass can be accomplished with high efficiency (Strehler and Stützle, 1987). The disadvantages of gasifiers include a high particulate and tar content of the gas. Furthermore, current gasifier designs do not accept all types of crop residues.[26] Finally, after biomass burns, a silicate remains, creating a sludge problem that inhibits acceptance of residues as an alternative fuel.

Using agricultural residues to manufacture paper products is a possible alternative. Traditionally, paper products are manufactured using wood chips, which are cheap and readily available. However, wood chips do not require storage from rainy weather and replacing them with agricultural residues may require major retooling in the wood fiber industry. Despite this, however, grass straw is becoming a more economically attractive alternative to using hardwoods. The reason for this is the projected shortage of hardwoods in the near future and the fact that straw fibers from grass seeds are very similar in structure to hardwoods.

POLICY OPTIONS

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[26] For a more complete technical discussion of agricultural residues as an alternative fuel source, see Strehler and Stützle, 1987).

Currently, significant scientific uncertainty inhibits development of programs in this field. Therefore, research and development projects which support alternative uses for agricultural residues could prove extremely beneficial. States could encourage alternative uses for crop residues by designing policies compatible with those mentioned in Section 5.12.1 and Section 5.2, which address the advantages of using biofuels and renewable energy sources for energy production, including co-generation and direct combustion.

- *Provide Information*. Information dissemination campaigns may be an effective way to encourage alternative uses for crop residues. Given information on these alternatives, farmers may be convinced to participate in voluntary emissions reduction programs to reduce smoke and particulate emissions as well as greenhouse gases. Though information is available on composting, most farmers have little experience with this practice. States can disseminate information describing the potential soil benefits associated with this option, the manner in which it can be implemented, and conditions under which it works best. The Cooperative Extension Service is an appropriate state vehicle for this.

- *Support Research and Development*. Ideal composting methods need to be identified and a better understanding of large-scale composting achieved, before widespread adoption can be expected. In addition, states can fund projects that investigate the viability of alternative uses for crop residues. For example, states can provide funding to support research into wood product substitution for grass straw. To date, a number of studies have indicated the great potential that biomass fuels have as an alternative fuel source. This issue needs to be examined further.

5.12.3 Use Alternative Burning Techniques

DESCRIPTION

A number of alternatives that still involve burning can also reduce emissions. This can be accomplished, for example, either by creating a hotter, more controlled burn that combusts crop residues more thoroughly, or by reducing the frequency of burning in conjunction with mechanical crop removal techniques. Technologies and methodologies to achieve these objectives include:

- *Mobile Field Sanitizer*. This is a machine designed to burn agricultural residues in place. It serves as a method of both straw removal and field sanitation. While field tests have shown that sanitizers can reduce carbon monoxide and hydrocarbon emissions, their applicability appears limited. Technical and economic evaluations of field sanitizers have found problems with high operating costs, durability, maneuverability, energy use, and operating speed. Based on these studies, many states have discontinued research and development of mobile field sanitizers, although there has been some success with their private development.[27]

- *Propane Flaming*. Propane flamers consist of a propane tank and a series of nozzles. The propane is released, ignited, and directed at ground level. Because straw residue must be removed first for this method to be effective, this technique is typically used with other disposal methods such as bale/stack burning (described below). While these practices are thought to bring about a slight reduction in emissions when used together, they are much more time consuming than open

[27] For example, an Oregon farmer currently uses a privately-developed mobile field sanitizer. Due to the high value of this farmer's crop, it was economical to develop and maintain the sanitizer (U.S. EPA, 1992b). The high costs associated with development frequently prevent other farmers from pursuing this option.

field burning. If most of the straw residue is removed prior to flaming, this technique should not result in major seed yield losses.

- *Bale/Stack Burning*. Bale/stack burning, the collection of crop residues into bales or stacks to facilitate controlled burning, is a companion practice to propane flaming (which requires straw removal). Some growers have turned to bale/stack burning to dispose of unmarketable crop residues. As mentioned above, this practice results in slight reductions in emissions, but is more time consuming than open field burning.

- *Less-Than-Annual Burning*. This involves alternating open field burning with various methods of mechanical removal techniques. The periods may involve burning every second or third year.

CONSIDERATIONS

There are a number of uncertainties that limit the applicability of some alternative burning techniques. For example, mobile field sanitizers have not been fully developed and have proven successful only in isolated cases. The technical problems associated with field sanitizers mentioned above need to be addressed before widespread acceptance of this option can be expected. Similarly, improvements in techniques like propane flaming may be required to make it an attractive alternative. For example, studies have shown that because of the temperature and duration of propane flaming, many of the weed seeds are not destroyed, ultimately resulting in increased weed infestation (U.S. EPA, 1992b). Moreover, the fossil energy inputs required for these techniques emit greenhouse gases, so the net effect on emissions is not clear. These problems will need to be addressed in order to facilitate acceptance of these alternatives.

POLICY OPTIONS

States could encourage alternative burning techniques for crop residues by designing policies compatible with those mentioned in Section 5.12.1. Specifically, states may wish to focus on research and development efforts or demonstration projects to eliminate some of the problems and uncertainties discussed above.

5.12.4 Replace with Alternative Crops

DESCRIPTION

Crops whose residues are typically burned can be replaced with crops that potentially grow and thrive under a system of non-burning, such as meadowfoam, rapeseed, and Pyrethrum. Switching crops in this way is highly dependent on economic, agronomic, institutional, and other factors. This is an area of current research and relatively high uncertainty regarding net impact on greenhouse gas emissions.

CONSIDERATIONS

Whether this alternative is feasible depends on its ability to compete economically and its agronomic capabilities compared with existing crops. Limited potential for major crop shifts exist where crop patterns have developed in accordance with agronomic conditions and market demands.

Research in Oregon has shown that alternative crops with the best agronomic viability have not been economically competitive with perennial grass seed production in the Willamette Valley. In

California, rice farmers have been reluctant to stop farming rice because the high clay soils are unsuitable for growing other crops (U.S. EPA, 1992b). Further research may determine whether there are crop species that thrive without open field burning and that approach production levels of existing crops.

POLICY OPTIONS

- *Support Research and Development*. Research programs are necessary to determine economically feasible substitutes for crops whose residues are typically burned. The USDA/ARS and CSRS support research into new crops. Much of the current research on the use of alternative crops has taken place in Oregon. The results of this type of research are often specific to a state and/or region.

CHAPTER 6
CROSS-CUTTING THEMES AND PROGRAM DEVELOPMENT

This chapter introduces potential organizing principles for policy development that span the various greenhouse gas source categories examined in Chapter 5. The approaches presented here offer some of the most significant opportunities for large-scale emission reductions, and may serve as focal points for coordinating long-term, comprehensive planning for reducing emissions.

Programs that affect various source categories usually focus on either one economic sector, one particular type of policy, or a more specific substantive goal. For example, a program may target the energy or the agricultural sector, or may target municipal solid waste. Alternatively, a program may establish an energy or carbon tax that affects various sectors. Finally, a program may focus on a substantive issue such as biomass energy development or public education.

While the specific cross-cutting options presented here offer potential for large emission reductions, policy-makers may want to develop other sectoral or substantive focal points that match their local circumstances. Programs in each region of the country should certainly respond to local needs and make full use of local resources such as available wind, solar power, or other renewable energy sources. Customized programs that cut across source categories are especially promising in areas dominated by one type of economic activity such as agriculture, forestry, or coal mining. In these areas, comprehensive programs can foster diverse policies that support each other even though they address different greenhouse gas sources. For example, comprehensive agricultural programs can simultaneously utilize methane from waste products for on-site power production, increase energy efficiency, and reduce transportation emissions stemming from waste disposal.

This chapter discusses six specific cross-cutting topics:, (1) energy conservation, renewable energy, and carbon offsets in the electricity sector, (2) municipal solid waste management, (3) biomass based energy development, (4) carbon sequestration through forestry, (5) city and regional planning, and (6) agricultural sector planning. This information is meant to provide background for policy development across greenhouse gas source categories by introducing these concepts and referring policy-makers to related and more specific information in Chapter 5. In most circumstances the information presented here is not as detailed as in Chapter 5. For more information on the linkage between these two chapters, see the introduction in Part II of the document.

6.1 ENERGY CONSERVATION, RENEWABLE ENERGY, AND CARBON OFFSETS IN THE ELECTRICITY SECTOR

The recent trend toward deregulation of electricity generation is transforming the U.S. electricity sector. Electricity production previously involved only utilities constructing and operating power plants. However, the trend now is for utilities to compete with other firms in generating electricity, with utilities maintaining their historical role in transmission and distribution of electricity.

This section examines how states can promote greenhouse gas reductions within the context of electricity deregulation. It provides a background for the specific technical approaches and policy options presented in Sections 5.1 and 5.2. While separated here for clarity, these three sections supplement each other and should be considered together during policy analysis and development.

The remainder of this section summarizes five approaches states might either initiate directly or utilize for guidance.

Ensure Infrastructure Access for Small Power Producers, and Promote Purchase of "Green Power"

One potential environmental benefit of electricity deregulation is the opportunity for electricity consumers to choose to purchase power from generators using low-carbon fuel (i.e., natural gas) or no-carbon renewable fuels. For consumers to have this option, generators using low-carbon and no-carbon fuels must be able to connect to the electric utility grid, so that they may provide electricity over the utility's transmission and distribution system.

In the past, two factors have inhibited non-utility power producers from entering the electricity market. First, these producers face high costs in linking or "interconnecting" to power transmission and distribution networks. In addition, although the Public Utilities Regulatory Policy Act requires utilities to provide interconnections on nondiscriminatory terms and at just and reasonable rates, in practice, many non-utility power producers have encountered substantial resistance from electric utilities. Beyond the basic interconnection issue, non-utility power producers historically have had difficulty selling power directly to consumers (rather than to a utility as a middleman). State options to address these issues include increased scrutiny of utility interconnection and back-up pricing practices to ensure that they are nondiscriminatory to non-utility power producers, as well as policies to encourage electric utilities to provide transmission services for non-utility power producers.

Once consumers have the option of buying power directly from a variety of electricity generators (both utilities and non-utilities), the state government can encourage firms to offer "green power" (i.e., electricity generated with low-carbon or no-carbon fuels). At the same time, the state government could publicize the greenhouse gas benefits of green power, to increase demand for this environmentally friendly option.

Institute a "Societal Benefits" Charge or a Carbon Tax on Electricity Generation

At least three states (Massachusetts, California, and New Jersey) have instituted a tax, often termed a "societal benefits" charge, on all electricity purchased (no matter what fuel is used to generate the electricity). Proceeds from this tax are typically used to promote energy efficiency and renewable energy through research and development funding, production subsidies, tax credits, low-interest loans, or other means. Other uses of the tax proceeds include helping low-income households pay for their energy needs.

An alternative approach would be to institute a carbon tax on fossil fuels used for electricity generation. A carbon tax may reduce greenhouse gas emissions by encouraging energy efficiency or fuel-switching to low-carbon energy sources. Note, however, that although related measures, such as "externality-adders" or gasoline taxes, have been employed at the state level, a carbon tax at the state level may result in undesired consequences. For example, it might provide incentives for industrial and commercial energy consumers to relocate outside the state.

Promote voluntary adoption of energy-saving technologies

In the past, some states have become involved in promoting energy efficiency by encouraging electric utilities to help their customers purchase energy-efficient equipment. Such programs were known as “demand-side management,” or DSM. DSM programs contributed to “integrated resource planning, ” or IRP (in which future electricity demands were met by investments both in energy-efficient equipment and in new generating capacity). With the trend toward deregulation of the electricity sector, many states are turning away from the utility-focused DSM and IRP programs. However, states still have opportunities to promote voluntary adoption of energy-saving technologies. For example, a state government could provide one-stop shopping for information on how to participate in a variety of federal energy conservation programs, from the US EPA’s Green Lights program to the US Department of Energy’s Motor Challenge program.

Establish or Support Carbon Offset Programs

States could require, or provide financial incentives to encourage, electricity generators and other greenhouse gas producers to reduce emissions or sequester carbon in proportion to the emissions that new activities, such as a new power plant, will create. One option is to allow these emissions reductions to take the form of "offsets", *i.e.*, a utility that wants to construct a new coal-fired power plant, for example, could be required to sponsor a carbon sequestration forestry project or a program to reduce emissions in some other sector, such as transportation. Combining the emissions offset project and the new power plant project would aim to ensure that there is no net increase in the amount of greenhouse gases emitted to the atmosphere.

In addition to directly mitigating the impacts of emissions from new sources, these types of "offset" programs provide an incentive for utilities to select non-carbon energy sources when feasible. This is because requiring carbon offsets will raise the costs of high-carbon options, making alternative energy sources relatively more desirable.

With these factors in mind, some states and utilities are beginning to pursue offset programs as one of the most promising options for mitigating the impact of energy related emissions. Applied Energy Services, for example, pioneered a forestry project in Guatemala to offset the emissions from a 100 megawatt coal-fired power plant in Connecticut and the New England Electric System is sponsoring similar projects in Russia and Malaysia.

Several issues complicate offset program design and administration. Many are related to the fact that large scale offset programs are a relatively new and undeveloped technique that will presumably be refined. Another constraint is the difficulty associated with measuring the greenhouse gases emitted and sequestered through various activities, especially long-term forestry projects where success depends on many climatic and other uncontrollable factors. Issues of predictability and dependability become more significant if offset programs permit investment in forestry projects in other parts of the world, where the projects usually cost less. Further, states pursuing offset options will also have to evaluate how to treat emissions linked to electricity received from or sent to other states or offset projects located in other states.

Support Emission Trading Programs

Emissions trading programs allow private entities to buy and sell pollution reductions that are achieved. These market-based systems present opportunities for reducing aggregate pollution levels at a lower cost to society. Forms of tradeable permit systems, for example, are currently utilized in the U.S. to control non-greenhouse pollutants including sulphur dioxide and lead. These programs provide broad incentives to all polluters to reduce emissions and improve their production processes and could conceivably be applied to carbon dioxide emissions as well, either domestically or internationally. Tradeable permit programs may not be feasible or desirable at the state level, however, because of complications arising from complex cross-boundary, administrative, and enforcement issues. They are noted here as background on national or regional initiatives that states might support in order to help reduce their own emissions.

In one form of tradeable permit system, the government sets an aggregate level of permissible emissions for society as a whole and then allocates permits that allow their holders to emit a certain quantity of pollutants. Private entities that want to increase their levels of pollutants (presumably to increase production of their products, such as electricity) must buy permits from others who hold permits in excess of their current needs. In this way, the government achieves its target level of aggregate emissions at a minimum social cost and simultaneously provides an incentive for individual private sector actors to reduce emissions so they can gain profits by selling excess permits.

Complications in designing these programs include setting a target level of emissions, distributing initial permits, addressing equity concerns in initial permit distribution between different polluters, designing the system for facilitating permit sales and purchases, dealing with cross-boundary issues, and determining the optimal allowable aggregate emission levels.

> Cross-cutting policies in the energy sector may affect all of the emission source categories in Chapter 5. For example, energy taxes will affect all methane and transportation issues in addition to traditional electricity production and consumption. As stated at the beginning of this section, it is particularly important that the information presented here be considered in the context of technical approaches and policy options in Sections 5.1 and 5.2.

6.2 MUNICIPAL SOLID WASTE MANAGEMENT

Continuing to promote the municipal solid waste hierarchy of waste management methods—i.e., promoting increased source reduction and recycling followed by combustion and landfilling of waste—can result in significant GHG reductions. States have a number of opportunities for increasing source reduction and recycling, thus achieving GHG reductions in the waste management sector.

As of late 1997, 45 states have statewide goals for source reduction and/or recycling (SR&R). Most of those goals were set at ambitious levels, and many states are in the process of re-evaluating the goals. As this section describes, the climate benefits of SR&R are significant; states may consider these benefits as they reevaluate their SR&R goals. Although GHG emissions from the waste sector typically represent just five to ten percent of a state's GHG inventory, they may represent up to 20 percent of the GHG reductions in a state action plan, due to GHG reductions across many sectors (e.g., energy-related GHGs, manufacturing non-energy GHGs, and landfill methane). EPA has conducted research to quantify the GHG benefits of SR&R, and is providing technical assistance to states developing mitigation plans for the waste sector.[1]

The way in which municipal solid waste (MSW) is managed affects GHG emissions in several ways. The use of energy in material production can be reduced (with accompanying GHG reductions) through source reduction;[2] the same is generally true for recycling. Source reduction and recycling can also reduce manufacturing non-energy GHG emissions (e.g., perfluorocarbons); in some industries—notably aluminum and steel—such emissions can be significant. In the short run, the amount of carbon sequestered in forests will increase when paper is source reduced or recycled (because timber harvests will be reduced). Methane emissions from landfills can be reduced by managing the organic fraction of MSW by means other than landfilling. However, in a properly managed landfill, landfilling can serve as a long-term carbon sink for organic materials. Exhibit 6-1 shows the GHG sources and sinks associated with materials in the municipal solid waste stream.

Source reduction and recycling in one state may in some cases result in GHG reductions in another state. For example, a state that recycles office paper may as a result reduce energy consumption (and CO_2 emissions) in another state where office paper is manufactured. If the first state exports its waste for landfilling out of state, it may also reduce landfill methane emissions in a third state. The same phenomenon can occur with state programs to reduce energy consumption: because many states import electricity, one state's efforts to reduce electricity consumption may result in GHG reductions (from reduced electricity generation) in other states. With any type of state program that may result in GHG reductions out of state, it is important to remember that climate change is a global problem, and the state is still helping to reduce greenhouse gas emissions, and helping the nation to meet its international greenhouse gas commitments. Thus, a state program to reduce GHG reductions from MSW management is worthwhile, even though some of the GHG reductions may show up on other states' GHG inventories.

The EPA Office of Solid Waste (OSW) has quantified the GHG impacts of different methods of managing various components of MSW. In general, source reduction (including backyard composting), recycling (including centralized composting), and combustion have lower GHG emissions than landfilling. EPA plans to evaluate the GHG emissions of emerging technologies for MSW management, such as conversion of organic materials to biomass fuels.

This section examines five means by which states can promote greenhouse gas reductions through improved management of MSW. A useful reference for quantifying the GHG emission reduction benefits from source reduction and recycling of selected materials in MSW is a draft EPA report, *Greenhouse Gas Emissions from Municipal Waste Management*. The report is available on the Internet at http://www.epa.gov/epaoswer/non-hw/muncpl. Also, Appendix 2 of this guidance document presents a mock-up for a state solid waste climate change mitigation package.

Promote Voluntary Waste Prevention and Recycling in the Commercial Sector

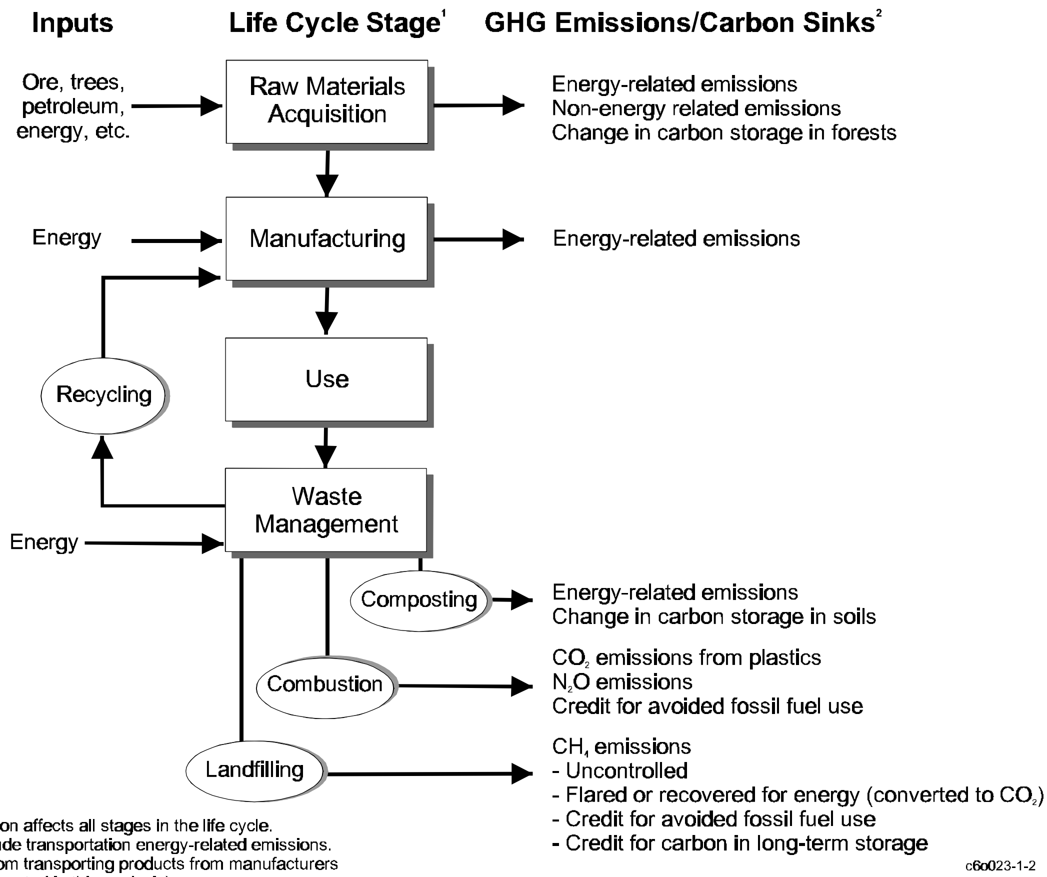
When businesses implement source reduction and recycling programs, they do so because it saves them money (e.g., by reducing waste disposal costs). Thus, from a state perspective, promoting voluntary

[1] To reach EPA staff that can provide technical assistance to state GHG planners on MSW management options, contact EPA's Municipal and Industrial Solid Waste Division (phone: 703-308-8300; fax 703-308-8686).

[2] Source reduction, also known as waste prevention, involves altering the design, manufacture, purchase, or use of products and materials to reduce the amount and toxicity of what gets thrown away. Source reduction reduces or eliminates pollution at the source.

commercial source reduction and recycling is a "no regrets" option: it makes sense even without considering the greenhouse gas reductions achieved. Offices, grocery stores, and other businesses often can source reduce and recycle large volumes of office paper, corrugated cardboard, and other materials. State governments can foster commercial source reduction and recycling through a state government "buy recycled" program, and incentives such as business development assistance and tax cuts or tax credits.

Exhibit 6-1
GHG Sources and Sinks Associated with Materials in the MSW Stream



[1] Note that source reduction affects all stages in the life cycle.
[2] All life cycle stages include transportation energy-related emissions. (except that emissions from transporting products from manufacturers to consumers were not counted in this analysis).

EPA's WasteWi$e Program is a flexible program that allows partners to design their own solid waste reduction programs tailored to their needs. It challenges companies to set and achieve source reduction and recycling targets. EPA offers technical assistance and recognition to partners (the entitities who commit to achieve waste reduction) and endorsers (groups who help promote WasteWi$e). States, local governments, and tribes can sign on as partners; many (85) have already joined the program in this capacity. Also, over 600 businesses currently participate in the WasteWi$e Program. By diverting waste from disposal, these programs reduce waste collection and disposal costs, reduce greenhouse gas emissions, and reduce other environmental emissions as well. Information on WasteWi$e is available from EPA's hotline for the program (1-800-EPA-WISE) or the program's web site (http://www.epa.gov/wastewise).

Promote Collection Efficiency for Recyclable Materials and Maximum Diversion Programs in the Residential Sector

Small cities in the US have been able to achieve recycling rates of 50 percent or more, while some large cities are approaching a 50 percent recycling rate. Loveland, Colorado (population 44,300) has achieved a 57 percent recycling rate by providing curbside recycling and charging volume-based trash fees for waste disposal. Ann Arbor, Michigan (population 112,000) recovers 50 percent of its residential waste through curbside recycling of 30 different recyclables. San Jose, California (population 850,000) recovers 44 percent of its waste, including 55 percent of waste from single-family households, which pay volume-based rates for trash service.

The best means of achieving GHG reductions from increased recycling in the residential sector is often to institute curbside recycling. Compared to a recycling program based on drop-off centers, curbside recycling dramatically increases both participation in recycling, and the amounts of material recycled. Curbside recycling is most cost-effective in larger communities, where marketable quantities of recyclables may be collected each week. Thus a state may consider encouraging larger communities to provide curbside recycling. Some communities combine curbside recycling with waste collection by using "co-collection" trucks with bins for each type of recyclable material, plus a compartment for non-recycled waste.

Some cities have focused on increasing the efficiency of their waste management operations (thus decreasing costs), and increasing recovery at the same time. Some of the techniques used to increase efficiency include increased automation, changes in collection frequency, and improved routing. Rochester, New York and Mesa, Arizona both instituted curbside recycling as part of an overall efficiency upgrade. The amount of materials recovered increased from zero to six pounds per household per week in Rochester, New York, and from zero to ten pounds per household per week in Mesa, Arizona.

Institute "Pay As You Throw" Pricing for Waste Collection

"Pay as you throw" (PAYT) programs may be implemented to further increase recycling, and to provide an incentive for source reduction. Under a PAYT program, households are charged for the amount of waste they discard. By increasing the amount of waste that they recycle and source reduce, households can reduce the amount of discarded waste and thus will reduce waste disposal costs. PAYT programs have traditionally charged households for the *volume* of waste disposed, measured by a standard-sized bag or trash can. Where bags are used, households must either pay for each specially-marked bag they use, or pay for pre-printed stickers to place on each ordinary trash bag they set out. Where containers are used, a household pays a monthly or annual fee for the size and number of containers it uses.

Over 3,000 communities have implemented PAYT programs, with many communities reporting average waste reductions ranging from 25 to 35 percent. Information on PAYT is available through the web site maintained by EPA's Pay-As-You-Throw program (http://www.epa.gov/payt) and the program's help line (1-888-EPA-PAYT).

Target Specific Materials in the MSW Stream

Many communities have instituted programs to divert specific materials from landfills. Such programs have ranged from promoting composting of grass clippings to collecting second-hand electronic goods for repair and resale.

Several communities in the U.S. collect durable goods for reuse. Programs include curbside collection of durable goods for distribution to charities, local swap meets where individuals may trade durable goods, or drop-off sites where individuals may leave goods that are broken or no longer of use to them, and others may take what they can fix or use. States may promote such programs by emphasizing the full range of benefits, including reduced disposal costs, greenhouse gas reductions, and, where applicable, employment opportunities (e.g., repairing electronic goods).

A state may reduce emissions of methane from landfills by reducing landfilling of grass clippings. Grass clippings from a state with a population of 5 million, which generates grass clippings at the national average rate, will emit about 103,000 metric tons of carbon dioxide equivalent (MTCDE) of methane if landfilled. Because grass clippings decompose readily, they generate more methane when landfilled than leaves, branches, and many other types of organic wastes. Grass clippings may be kept out of landfills through "grasscycling" (leaving grass clippings on the lawn to decompose) or composting. Many communities have successfully implemented backyard composting programs by giving residents free plastic composting bins. Collection of grass clippings for centralized composting is another alternative.

Ensure Adequate Financing of Source Reduction and Recycling Programs

States can help to expand source reduction and recycling efforts by establishing financing mechanisms for support of new programs. Alameda County, California imposes a surcharge of six dollars per ton of waste landfilled in the county, to support waste reduction and recycling. The fee has generated more than 30 million dollars in revenues since 1991. This surcharge not only ensures revenue for waste reduction activities but also creates financial incentives to reduce the amount of waste landfilled. Other types of financing could also be developed.

For more information on municipal waste management issues see:

5.1 Greenhouse Gases from Energy Production: Demand Side Measures
5.6 Methane from Landfills
5.11 Emissions Associated with Forested Lands

6.3 BIOMASS ENERGY DEVELOPMENT

Biomass resources, including wood and agricultural wastes, timber, and grain crops accounted for about 3.3 percent of U.S. energy consumption in 1990. Because plants that produce these resources sequester carbon while growing, using biomass as a renewable energy source to displace fossil fuels helps mitigate carbon dioxide buildup in the atmosphere. Additional information on how trees and plants sequester carbon is presented in Section 5.11, *Emissions Associated with Forested Lands*, and Section 6.3, *Tree and Timber Expansion Programs*.

Biomass can be converted to gaseous, liquid, or solid fuels that may substitute for common transportation, power generation, industrial, and heating fuels now used. Gaseous fuels from biomass can be used just like natural gas. Liquid fuels, mostly ethanol and similar alcohol products, can directly substitute for liquid petroleum fuels such as gasoline. Solid fuels, usually meaning the biomass itself after being dried, can be burned to produce thermal energy for uses like heating buildings or can be used in direct combustion processes at power plants in the same way as coal.

Wood wastes and agricultural crop residues are often considered to be the most cost-effective biomass resources since they result from other productive economic activities and are readily available. Wastes and residues are currently used extensively for energy production in some sectors such as the paper industry. In addition to replacing fossil fuels that produce greenhouse gas emissions, increasing the use of these resources may help alleviate other problems such as costs and methane production associated with waste disposal and landfills. Wood and crop residues can be gasified, liquified (into ethanol), burned directly for use in on-site power generation, or burned to heat commercial buildings and homes.

Short rotation woody crops, mostly trees, can be burned to heat buildings or to fire conventional power plants in a process similar to coal combustion. For example, in 1990 New York state generated around 3 megawatts of electricity using wood power and in 1991 Vermont generated approximately 1.7 percent of its electricity from biomass at a woodchip burning plant. Wood can also be transformed into liquid fuels such as ethanol through enzymatic processes, although these processes are expensive to use at the current time. Several short-rotation woody crops have been identified as "model" energy crop species based on their rapid biomass yield potential. These crops include silver maple, sweetgum, sycamore, black locust, eucalyptus species or hybrids, and poplar species or hybrids. The highest yielding crop appropriate for a given region may be among these model crops or may be different, depending on soil and other characteristics within a geographical region (Sampson and Hair, 1992).

Grain crops, especially those high in sugar content such as sugar cane and corn, can be converted to ethanol through fermentation and distillation processes. This procedure is being pursued aggressively in some areas, especially throughout the corn-belt states where various programs promote ethanol to enhance energy self-sufficiency and support the local economy. Residues from these crops can also be used for direct combustion or gasification, as described above.

The challenge for biomass in the future is to ensure a sustainable harvest, possibly from plantations, to develop efficient and non-polluting systems for fuel conversion and use, and to lower production costs so these fuels can compete with traditional sources. The total costs of biomass fuel development will vary depending on crop productivity and biomass handling and transportation costs. Other questions surrounding biomass fuel development include the net effect of sequestering carbon (including impact on carbon content in soils), the effect on other greenhouse gas emissions like nitrous oxide from fertilizer applications, the vulnerability of large plantations to pests and diseases, the competition for woody biomass to make pulp for paper manufacturing, and competition for land with traditional agricultural crops (NAS, 1991).

- A variety of policy options may help resolve these uncertainties and promote greenhouse gas reductions through substitution of biomass fuels for fossil fuels. Policies in this area might include:

- Research, pilot programs and financial incentives to encourage the development of high-quality, low-cost, and continuously available bioenergy crops. Tax or other credits for biomass production or reducing tax incentives for fossil fuels may help in this way.

- Research and demonstration projects to encourage the development and application of more efficient technologies that may be more competitive with other sources of energy.

- Testing or construction of commercial facilities and infrastructure for using and distributing biomass-based fuels in order to support their widespread use in the long-term.

The 1991 Vermont Comprehensive Energy Plan illustrates how states might promote biomass fuel development, emphasizing how wood products can offset the state's use of nonrenewable fuels like coal or oil for electricity generation as well as direct heating. Similarly, the 1992 Iowa Comprehensive Energy Plan emphasizes increasing that state's energy self-sufficiency by developing renewable resources including ethanol and other biomass products.

> For more information on biomass issues see:
>
> 5.2 Greenhouse Gases from Energy Production: Supply Side Measures
> 5.3 Greenhouse Gases from the Transportation Sector
> 5.6 Methane from Landfills
> 5.10 Nitrous Oxide from Fertilizer Use
> 5.11 Emissions Associated with Forested Lands

6.4 TREE AND TIMBER EXPANSION PROGRAMS

Trees provide an important terrestrial "sink" for carbon dioxide by removing or sequestering this greenhouse gas from the atmosphere as they grow, and storing it in wood, foliage, and soils. Permanently increasing the acreage devoted to forests and timberland can therefore contribute to reducing net carbon emissions. Policies to pursue this aim can be valuable in "offsetting" or counter-balancing emissions from other sources such as power plant operations. This section focuses specifically on increasing carbon sequestration through expansion of forested lands; Section 5.11, *Emissions Associated with Forested Lands*, provides more details on emissions issues related to conversion of existing forest land and consumption of wood products.

Carbon sequestration benefits may accrue through projects designed specifically for this purpose or they may accompany broader policy objectives such as enhancement of natural resources, reduced soil erosion, or improved wildlife habitat. Several federal level forestry programs and planting initiatives and some private sector efforts support tree planting objectives. The federal programs are administered primarily by the U.S. Forest Service and other agencies within the U.S. Department of Agriculture and by the Department of the Interior.

One of the most significant federal efforts dedicated to expanding forested area in the U.S. was the U.S. Tree Planting Initiative. As part of the 1990 Farm Bill, this initiative focussed on planting and maintaining one billion trees per year in urban and rural areas. Linked with this initiative are existing federal programs, including the Stewardship Program, the Stewardship Incentive Program, and the Urban and Community Program, that work towards the goal of tree maintenance and planting. All 50 states have formed State Forest Stewardship Coordinating Committees to assist state foresters with these programs.

Federal programs designed to meet other policy objectives may also help increase carbon sequestration through tree and timber expansion. For example, the Conservation Reserve Program, aimed at protecting highly erodible croplands, converted about 2.4 million acres into permanent tree cover since its inception (Callaway and Ragland, 1994). Carefully tailored support for this sort of initiative illustrates the types of multiple-benefit or "no regrets" actions that states may be able to pursue to help mitigate the threats of climate change.

Additional tree-planting initiatives have been undertaken by electric utilities, often with the assistance of state governments and some non-governmental organizations, in an effort to "offset" carbon emissions from other sources, including power plant operations. For example, PacifiCorp is implementing carbon dioxide offset projects in Oregon that assist non-industrial landowners in planting rural lands. This project includes cost-sharing and a requirement that trees not be harvested for at least 65 years. American Forests' *Global ReLeaf for Energy Conservation Program* is also focusing on encouraging utility companies to plant trees for energy conservation.[3] Further, New England Electric Systems is sponsoring forestry programs in Malaysia and Russia to offset emissions from their U.S. based generating stations. Section 6.1 discusses utility offset programs in more detail.

Tree and timber expansion programs in general may include reforestation (replanting former forests) and afforestation (converting other land uses to trees). Either way, the net amount of carbon dioxide that is sequestered annually by new tree growth varies with the quality of the land, the age of the tree and its species, climate, and other factors. For example, southern pines planted on cropland may sequester about 22 percent more carbon per acre than pines planted on pasture land in the southeast (Birdsey, 1992). At the same time, however, slower growing tree species that offer longer crop rotation periods or wood that can be used in longer-lived products, such as furniture, may supersede the apparent carbon benefits of faster growing species planted in the same regions.

Policy options to support tree planting include: planting programs on public lands, direct payments or tax subsidies for private sector tree planting, partnerships or educational seminars targeted at timber and other forest interests, technical support for non-profit or other private groups, and forestry based carbon offset programs. The real range of opportunities in this area depends on local circumstances including perspectives shared by different interests involved in the forestry sector.

Because of this diversity of policy options and the technical complexities and uncertainties involved in forestry expansion programs, the design of large-scale tree planting programs is critical to their success in sequestering carbon over time. Programs that do not adequately consider certain important interests in the tree and timber industry may even neutralize the carbon sequestration benefits they are trying to achieve. For example, private forest owners not enrolled in new government forestation programs may reduce their own tree planting because they anticipate lower timber prices when surplus government timber is harvested. This may result in less net carbon sequestered by the government program. As another example, because much of the carbon stored in the soil and in the woody biomass of the tree is released when the tree is harvested, carbon benefits are reduced if the land planted under the program does not remain permanently forested. Assuring that the planted trees remain in the ground may require long-term commitments by landowners.

It is also important to note that most subsidies for tree planting do not preclude harvesting. Net effects on carbon sequestration may, therefore, be unclear, especially if energy consumption associated with harvesting activities is considered. Further, tax incentives and other subsidies must be carefully crafted to encourage incremental behavior -- *i.e.*, to avoid rewarding individuals for activities that were already planned. At the same time, care must be taken to avoid penalizing the forest industry and other individuals already engaged in the desirable activity of planting trees -- making these actors ineligible for benefits under a tree planting program may be counter-productive.

[3] American Forests is a non-profit organization in Washington, D.C.

Federal tree planting programs have employed a number of different methods to induce individuals to participate and to ensure long-term success. For example, the Conservation Reserve Program employs cost-share arrangements that cover a variety of land management and treatment costs, such as site preparation, planting, and thinning. Technical assistance has been a component of the Stewardship Incentive Program. In addition, these programs typically specify land and landowner eligibility requirements in order to prevent perverse results, such as clearcutting and replanting in order to receive subsidies.

One example of a state level forestation program is the Missouri Department of Natural Resources' *Operation TREE* (Trees Renew Energy and the Environment). This program's goals are to reduce demand for heating and cooling with strategic landscaping, to remove carbon dioxide from the atmosphere, to arrest soil erosion, and to enhance natural water filtration. The Division of Environmental Quality also incorporated a land reclamation program for mine sites into Operation TREE. Because mine sites are typically steep and the soil is of poor quality, they are often more amenable to trees than to other types of cover.

In addition, Minnesota recently completed a major report assessing that state's carbon dioxide budget and making recommendations for reducing emissions with forestry. They conclude that, while land availability is a constraint on carbon sequestration forestry projects, tree planting could be an important component of an overall program to reduce net carbon dioxide emissions.

6.5 CITY AND REGIONAL PLANNING

Coordinated urban and suburban planning of energy issues can lead to substantial greenhouse gas reductions. These reductions will stem largely from improvements in the transportation sector and from increases in efficiency during electricity consumption and production. They may also incorporate better use of urban and regional resources such as recyclable products, district heat, and methane from landfills.

The greatest opportunity for reducing emissions through city and regional planning stems not simply from achieving direct reductions in these areas, but rather from exploiting the interactions between different greenhouse gas producing activities. For example, the combination of a high density of dark buildings in urban areas and high levels of energy consumption that generates heat, such as vehicle traffic and commercial building energy use, tends to trap heat, creating an "urban heat island" effect. This can lead to demand for more air conditioning, refrigeration, and other energy draining activities. Similarly, a commercial building's energy requirements depend not only upon the building's construction and source of energy but also its external environment, including the density and distribution of surrounding buildings and the local climate. Additionally, the proximity of peoples' jobs to where they live is a key determinant of how much energy or fuel is consumed for transportation purposes. By addressing these issues through land use planning and community design, coordinated city and regional planning offers tremendous opportunity for reducing aggregate emissions of greenhouse gases.

State and local governments have the predominant jurisdiction to enact policies that will promote these types of reductions. City and regional planners determine where and how residential, commercial and industrial development takes place, states frequently set energy-efficiency standards and localities enact building codes, and both these levels of government plan and support transportation system development. In this context, local control over land use and zoning offers one of the greatest opportunities for promoting greenhouse gas emission reductions. It is important to realize that zoning ordinances affect these emissions whether they intend to or not, and therefore, that city and regional planners should become aware of the climate change implications of their actions. Zoning that permits extensive parking in urban areas, for example, often discourages the use of energy efficient public transportation. Similarly, zoning that excludes businesses from residential areas creates a higher need for mobility as people must travel farther to work, causing higher levels of emissions.

Planning agencies are also optimally situated to identify areas where excess heat or other resources in one sector, like industrial production, might be used to meet the energy needs in another sector, like commercial heating. This is a function that only local and state governments can perform.

The US EPA's $mart Growth Network provides resources to government, business, and civic sector leaders interested in developing cities and towns in ways that are environmentally, economically, and socially "smart." The network's mission includes encouraging (1) transit- and pedestrian-oriented development and (2) infill development in urban areas, to reduce suburban sprawl. Both of these policies help to reduce the use of automobiles, and thus help reduce greenhouse gas emissions from the transportation sector.

Exhibit 6-2: The Land Use, Transportation, Air Quality (LUTRAQ) Project

1000 Friends of Oregon, a nonprofit membership organization dedicated to the wise and responsible use of land, has initiated a research demonstration project to identify and analyze alternative development patterns to automobile-dependent suburban sprawl. By emphasizing the connections among land use, transportation, and air quality planning, the project participants hope to demonstrate how changes to local land use policies and development designs can increase the economic feasibility of alternatives to automotive travel, thereby reducing energy consumption; reduce the demand for automobile-oriented facilities; increase mobility for all segments of society; provide for sustainable population and economic growth; minimize negative environmental impacts, such as climate change effects from increasing greenhouse gas emissions; and enhance community character and awareness.

The LUTRAQ project will study a proposed $200 million bypass freeway and a surrounding 115 square mile area in the Portland, Oregon metropolitan region. Using well-known transportation and air pollution models (EMME/2 and MOBILE4), the project will identify replicable methods for altering land use development patterns to promote pedestrian, bicycle, and mass transit travel. These new methods will provide important tools for policy makers, planners, and citizens calculating the feasibility of alternative modes of transportation. The project research will be conducted by a team of internationally recognized experts in the fields of land use planning, urban design, and computer modeling.

The International Council for Local Environmental Initiatives (ICLEI), an international association of local authorities dedicated to helping localities mitigate environmental threats and enhance the natural and built environments at the local level, works with local governments to identify these types of opportunities for reducing emissions of greenhouse gases and other pollutants. Through their *Urban CO_2 Project*, ICLEI works with the cities of Denver, Minneapolis, Miami, San José, Portland, and others on greenhouse gas emission reduction programs.

Specific measures to reduce greenhouse gas emissions through city and regional planning should focus on coordinating the proximity and mix of residential, commercial and industrial sites in order to help mitigate the urban heat island effect, reduce or facilitate transportation needs, and use potential energy-saving or emission-reducing resources that are currently being wasted, such as heat from industrial sites or methane from landfills. For example, In 1994, 16 San Bernadino jurisdictions prepared a "Land Use, Transportation, and Air Quality" manual in response to a mandate from California's South Coast Air Quality Management District. The focus of the document is to improve air quality through land use measures such as transforming auto-oriented subdivisions into pedestrian neighborhoods. Other specific planning ideas are presented below.

- Establish self-sufficient, mixed-use communities by ensuring that employment, shopping, entertainment, medical care, and similar services are located near residential areas in order to minimize transportation needs. Florida has developed several model communities with these purposes in mind, as reflected in Dade County's "traditional neighborhood development ordinance."

- Support *central district heating and cooling*, which involves capturing and channeling waste heat (usually from industrial facilities) or heat from a central boiler to meet heating needs in commercial or residential buildings. This may involve developing infrastructure to transfer the heat (as steam or hot water) between locations and planning industrial, manufacturing, commercial, and residential centers in relative proximity to each other. Almost half of the homes in Sweden are heated this way.

- Plan the density, distribution, color, and facades (may include glass-types) of buildings so heat can escape the city to help mitigate the urban heat island effect. Develop urban tree programs to provide summer shade and to act as shelter belts against cold winds in the winter that draw the heat from buildings.[4]

- Establish and enforce building codes and energy-efficiency standards that help minimize residential, commercial, and industrial energy consumption.

- Design and build "green space", *i.e.*, parks, urban green wards, etc., These green spaces can help reduce urban heat island effects, while also sequestering carbon dioxide.

- Facilitate and promote public transportation systems in coordination with all the other planning measures listed above, reducing direct carbon dioxide emissions from automobiles and decreasing transportation systems contributions to the urban heat island.

- Support innovative work and transportation alternatives such as telecommuting in order to reduce overall commuting needs, again reducing direct carbon dioxide emissions and urban heat trapping.

6.6 AGRICULTURAL SECTOR PLANNING

Concentrating on one sector of the economy can provide a useful focal point for comprehensive and well-coordinated policy development. As an example, the agricultural sector contributes to greenhouse gas emissions in a variety of ways. For example:

- Greenhouse gases are emitted through energy consumption during field operations and agro-chemical production, including fertilizers, pesticides, and herbicides;

- Greenhouse gases are emitted when agricultural crop wastes are burned;

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[4] Cool Communities is a voluntary program sponsored by DOE. The function of Cool Communities is to encourage the strategic planting of trees to provide shade and windbreaks to residential and commercial buildings, thereby, improving energy efficiency and reducing the urban heat island effect. These trees also serve as a carbon sink, contributing to the overall carbon reservoir both above and below ground. (Cool Communities is Action #11 of the CCAP).

- Methane is emitted from livestock and poultry manure, through enteric fermentation in domesticated animals, and from flooded rice fields;

- Nitrous oxide is emitted as a result of nitrogenous fertilizer use;

- Agricultural production decisions alter land use, which in turn affect greenhouse gas emissions; and

- Agriculture offers biomass fuel potential.

By focusing on the agricultural sector, therefore, policy-makers can integrate several greenhouse gas reduction measures into a single, comprehensive program.

The greatest opportunities for reducing greenhouse gas emissions in the agricultural sector may involve not only direct actions to address each of these sources, as Chapter 5 discusses, but also innovative approaches that combine policies so that emission reductions from one source support reductions from others. For example, methane can realistically be captured from some manure systems and used as an energy source in production processes or for heating buildings. This decreases direct methane emissions

For more information on measures particularly relevant to city and regional planning see:

5.1 Greenhouse Gases from Energy Consumption: Demand Side Measures
5.2 Greenhouse Gases from Energy Production: Supply Side Measures
5.3 Greenhouse Gases from the Transportation Sector
5.4 Methane from Natural Gas and Oil Systems
5.6 Methane from Landfills

and reduces the need for energy from traditional fossil fuel sources (see Exhibit 6-3). Additionally, composting crop residues and using them as fertilizer or growing leguminous crops where residues can be plowed into fields as a nitrogen source will reduce carbon dioxide emissions from crop burning and may help decrease nitrous oxide and other emissions associated with fertilizer applications. Similarly, processing crop residues into biofuels has multiple benefits.

States can usually promote these or other innovative mechanisms for reducing emissions from multiple sources through individual projects or by developing broader programs under which a range of specific actions can be undertaken. Projects might include, for example, improving the understanding and increasing the implementation of integrated pest management (IPM) activities. IPM has the potential to not only reduce the need for and use of harmful pesticides, but it can also increase efficiency and productivity, thereby, reducing emissions from energy-related activities. Another potential project could include improving the efficiency of nitrogen fertilizer use. This has the potential to not only result in lower emissions of N_2O from microbial activity occurring in the soil, but also lower emissions of CO_2 from electricity and natural gas consumption during the manufacture of fertilizer. Also, both projects offer benefits to the farmer in addition to environmental, including decreased health risks (from a reduction in pesticide use), increased productivity, and decreased energy costs.[5]

Exhibit 6-3: Broiler Litter Program in Alabama

The Broiler Litter Program is co-sponsored by the Science, Technology and Energy Division of the Alabama Department of Economic and Community Affairs and the U.S. Department of Agriculture's Tennessee Valley Resource Conservation and Development Council. This innovative program addresses improvements in energy efficiency, solid waste reduction, and agricultural productivity. In the pilot program, newspaper is shredded and blown over a poultry house floor. Baby chicks are then brought in and, within a couple of days, the shredded paper becomes matted and slick from the droppings and moisture. A few days later, the matted paper begins to break up. In six weeks, the broilers are taken to market, at which time either a new layer of paper is added to the floor or the floor is cleaned up and the process repeated. When the litter is collected from the poultry house floor, it is spread on crops as fertilizer or is mixed with feed and fed to livestock for its nutritional value.

Because farmers can reduce their purchases of commercial fertilizers, greenhouse gas emissions associated with the production and use of the fertilizer are reduced. In addition to the benefits to the farmer in feed and fertilizer savings, the Broiler Litter Program can enhance recycling efforts by creating demand for old newspapers and by decreasing the flow of wastes to the limited amount of available landfill space. Furthermore, the use of shredded newspaper for bedding also eliminates the need to truck in wood chips from as far away as 250 miles, thereby saving on fuel and transportation costs. Finally, farmers have also noticed decreases in their energy bills, primarily due to the insulating effects of the shredded newspaper. This reduction in fuel consumption results in lower CO_2 and other energy-related emissions. With more than 2,000 chicken producers in the four Alabama counties where project demonstrations are held, more savings are expected as the program gains popularity.

Public recognition or other rewards for farmers who reduce emissions from more than one source simultaneously may also enhance farmer interest in these activities. Support for demonstration projects in multiple-source emission reductions can also generate farmer interest, especially if coordinated with well-known and successful existing farms. Another successful approach may be to make sure that farmers receive a uniform and consistent message about the needs, benefits, and related opportunities for multiple-source emission reductions from all government programs with which they commonly interact. For example, a common message about the imperatives and benefits of emission reductions from state agricultural agencies, environmental agencies, extension agents, and even in trade journals and other publications can consistently reinforce the fact that farms can simultaneously reduce emissions and save money.

States may gain additional benefits by developing broader programs to coordinate all these types of projects. For example, Chapter 7 describes the Iowa Agricultural Energy Environmental Initiative, a wide-ranging program that serves as a base for a variety of efforts to reduce energy consumption and pollution in Iowa's agricultural sector. Under this program, a diverse range of projects are tied to a common theme,

[5] The CCAP provides detailed descriptions and analyses of voluntary programs designed to reduce pesticide use and increase the efficiency of nitrogen fertilizer applications (Actions #17 and #18, respectively).

garnering publicity and political support as well as resources from a variety of external sources. Without the central program in place, several diverse projects could not be linked to a common initiative and would not receive the same level of popular or political support.

> For more information on agricultural sector planning see:
>
> 5.1 Greenhouse Gases from Energy Consumption: Demand Side Measures
> 5.2 Greenhouse Gases from Energy Production: Supply Side Measures
> 5.3 Greenhouse Gases from the Transportation Sector
> 5.7 Methane Emissions from Domesticated Livestock
> 5.8 Methane from Animal Manure
> 5.9 Methane from Rice Cultivation
> 5.10 Nitrous Oxide from Fertilizer Use
> 5.11 Emissions Associated with Forested Lands
> 5.12 Greenhouse Gases from Burning of Agricultural Wastes